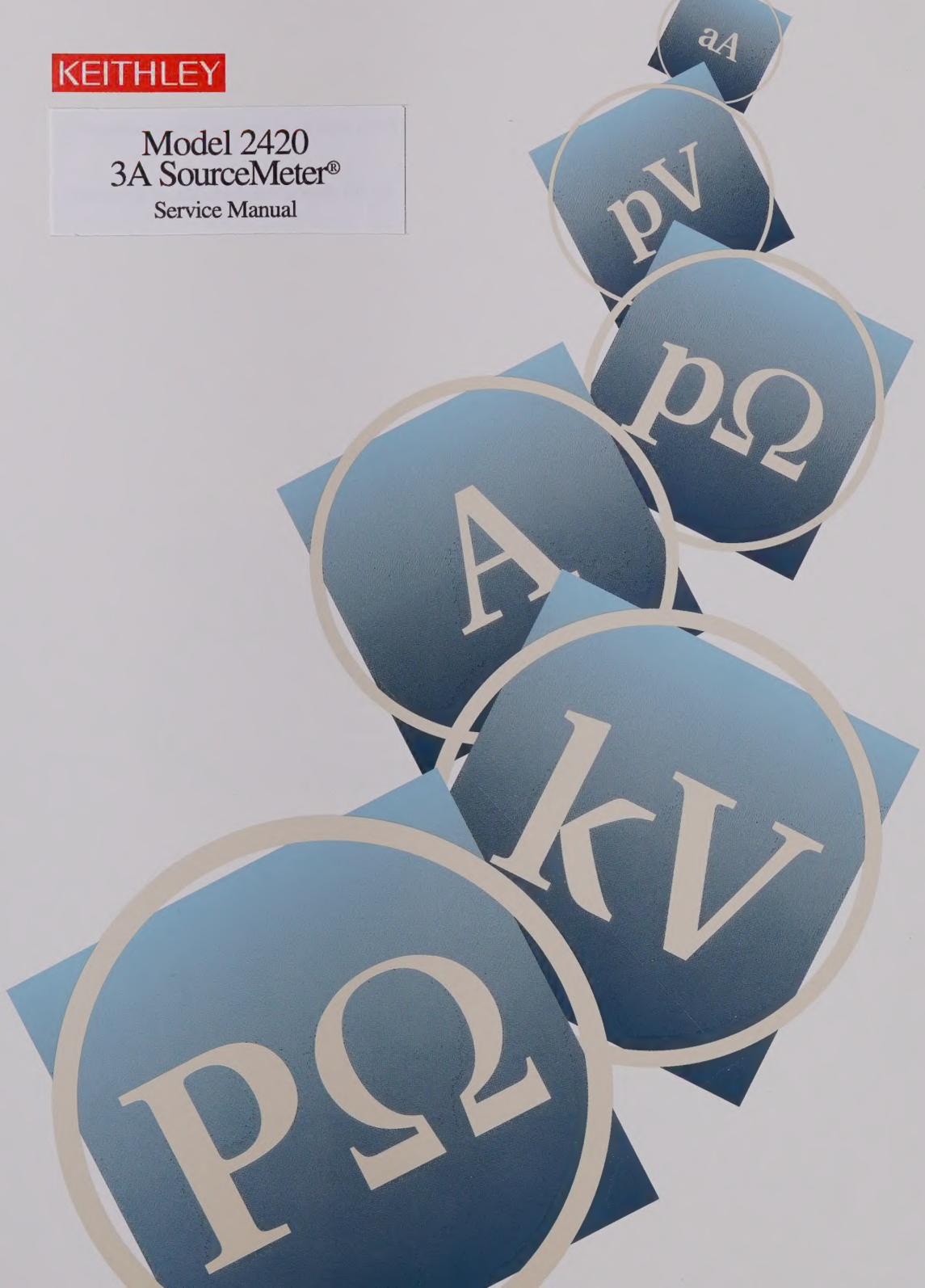
KEITHLEY

Model 2420
3A SourceMeter®
Service Manual



Model 2420
3A SourceMeter®
Service Manual

Contains Calibrating and Servicing Information

KEITHLEY

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Keithley Instruments, Inc. warrants the following items for 90 days from the date of shipment: probes, cables, rechargeable batteries, diskettes, and documentation.

During the warranty period, we will, at our option, either repair or replace any product that proves to be defective.

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Safety Precautions

The following safety precautions should be observed before using this product and any associated instrumentation. Although some instruments and accessories would normally be used with non-hazardous voltages, there are situations where hazardous conditions may be present.

This product is intended for use by qualified personnel who recognize shock hazards and are familiar with the safety precautions required to avoid possible injury. Read the operating information carefully before using the product.

The types of product users are:

Responsible body is the individual or group responsible for the use and maintenance of equipment, for ensuring that the equipment is operated within its specifications and operating limits, and for ensuring that operators are adequately trained.

Operators use the product for its intended function. They must be trained in electrical safety procedures and proper use of the instrument. They must be protected from electric shock and contact with hazardous live circuits.

Maintenance personnel perform routine procedures on the product to keep it operating, for example, setting the line voltage or replacing consumable materials. Maintenance procedures are described in the manual. The procedures explicitly state if the operator may perform them. Otherwise, they should be performed only by service personnel.

Service personnel are trained to work on live circuits, and perform safe installations and repairs of products. Only properly trained service personnel may perform installation and service procedures.

Exercise extreme caution when a shock hazard is present. Lethal voltage may be present on cable connector jacks or test fixtures. The American National Standards Institute (ANSI) states that a shock hazard exists when voltage levels greater than 30V RMS, 42.4V peak, or 60VDC are present. **A good safety practice is to expect that hazardous voltage is present in any unknown circuit before measuring.**

Users of this product must be protected from electric shock at all times. The responsible body must ensure that users are prevented access and/or insulated from every connection point. In some cases, connections must be exposed to potential human contact. Product users in these circumstances must be trained to protect themselves from the risk of electric shock. If the circuit is capable of operating at or above 1000 volts, **no conductive part of the circuit may be exposed.**

As described in the International Electrotechnical Commission (IEC) Standard IEC 664, digital multimeter measuring circuits (e.g., Keithley Models 175A, 199, 2000, 2001, 2002, and 2010) are Installation Category II. All other instruments' signal terminals are Installation Category I and must not be connected to mains.

Do not connect switching cards directly to unlimited power circuits. They are intended to be used with impedance limited sources. NEVER connect switching cards directly to AC mains. When connecting sources to switching cards, install protective devices to limit fault current and voltage to the card.

Before operating an instrument, make sure the line cord is connected to a properly grounded power receptacle. Inspect the connecting cables, test leads, and jumpers for possible wear, cracks, or breaks before each use.

For maximum safety, do not touch the product, test cables, or any other instruments while power is applied to the circuit under test. ALWAYS remove power from the entire test system and discharge any capacitors before: connecting or disconnecting cables or jumpers, installing or removing switching cards, or making internal changes, such as installing or removing jumpers.

Do not touch any object that could provide a current path to the common side of the circuit under test or power line (earth) ground. Always make measurements with dry hands while standing on a dry, insulated surface capable of withstanding the voltage being measured.

The instrument and accessories must be used in accordance with its specifications and operating instructions or the safety of the equipment may be impaired.

Do not exceed the maximum signal levels of the instruments and accessories, as defined in the specifications and operating information, and as shown on the instrument or test fixture panels, or switching card.

When fuses are used in a product, replace with same type and rating for continued protection against fire hazard.

Chassis connections must only be used as shield connections for measuring circuits, NOT as safety earth ground connections.

If you are using a test fixture, keep the lid closed while power is applied to the device under test. Safe operation requires the use of a lid interlock.

If a screw is present, connect it to safety earth ground using the wire recommended in the user documentation.

The symbol on an instrument indicates that the user should refer to the operating instructions located in the manual.

The symbol on an instrument shows that it can source or measure 1000 volts or more, including the combined effect of normal and common mode voltages. Use standard safety precautions to avoid personal contact with these voltages.

The **WARNING** heading in a manual explains dangers that might result in personal injury or death. Always read the associated information very carefully before performing the indicated procedure.

The **CAUTION** heading in a manual explains hazards that could damage the instrument. Such damage may invalidate the warranty.

Instrumentation and accessories shall not be connected to humans.

Before performing any maintenance, disconnect the line cord and all test cables.

To maintain protection from electric shock and fire, replacement components in mains circuits, including the power transformer, test leads, and input jacks, must be purchased from Keithley Instruments. Standard fuses, with applicable national safety approvals, may be used if the rating and type are the same. Other components that are not safety related may be purchased from other suppliers as long as they are equivalent to the original component. (Note that selected parts should be purchased only through Keithley Instruments to maintain accuracy and functionality of the product.) If you are unsure about the applicability of a replacement component, call a Keithley Instruments office for information.

To clean an instrument, use a damp cloth or mild, water based cleaner. Clean the exterior of the instrument only. Do not apply cleaner directly to the instrument or allow liquids to enter or spill on the instrument. Products that consist of a circuit board with no case or chassis (e.g., data acquisition board for installation into a computer) should never require cleaning if handled according to instructions. If the board becomes contaminated and operation is affected, the board should be returned to the factory for proper cleaning/servicing.

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1
Performance Verification

Introduction

Use the procedures in this section to verify that Model 2420 accuracy is within the limits stated in the instrument's one-year accuracy specifications. You can perform these verification procedures:

- When you first receive the instrument to make sure that it was not damaged during shipment.
- To verify that the unit meets factory specifications.
- To determine if calibration is required.
- Following calibration to make sure it was performed properly.

WARNING **The information in this section is intended for qualified service personnel only. Do not attempt these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages, which could cause personal injury or death if contacted. Use standard safety precautions when working with hazardous voltages.**

NOTE *If the instrument is still under warranty and its performance is outside specified limits, contact your Keithley representative or the factory to determine the correct course of action.*

Verification test requirements

Be sure that you perform the verification tests:

- Under the proper environmental conditions.
- After the specified warm-up period.
- Using the correct line voltage.
- Using the proper test equipment.
- Using the specified output signals and reading limits.

Environmental conditions

Conduct your performance verification procedures in a test environment with:

- An ambient temperature of 18-28°C (65-82°F).
- A relative humidity of less than 70% unless otherwise noted.

Warm-up period

Allow the Model 2420 to warm up for at least one hour before conducting the verification procedures.

If the instrument has been subjected to temperature extremes (those outside the ranges stated above), allow additional time for the instrument's internal temperature to stabilize. Typically, allow one extra hour to stabilize a unit that is 10°C (18°F) outside the specified temperature range.

Also, allow the test equipment to warm up for the minimum time specified by the manufacturer.

Line power

The Model 2420 requires a line voltage of 90 to 250V and a line frequency of 50 to 60Hz. Verification tests must be performed within this range.

Recommended test equipment

Table 1-1 summarizes recommended verification equipment. You can use alternate equipment as long as that equipment has specifications at least as good as those listed in Table 1-1. Keep in mind, however, that test equipment uncertainty will add to the uncertainty of each measurement. Generally, test equipment uncertainty should be at least four times better than corresponding Model 2420 specifications. Table 1-1 lists the specifications of the recommended test equipment, including maximum allowable uncertainty for alternate test equipment, which is shown in parentheses.

Table 1-1
Recommended verification equipment

Description	Manufacturer/Model	Specifications		
Digital Multimeter	Hewlett Packard HP3458A	DC Voltage*	1V:	±5.6ppm
			10V:	±4.3ppm
			100V:	±6.3ppm
		DC Current*	10µA:	±25ppm
			100µA:	±23ppm
			1mA:	±20ppm
			10mA:	±20ppm
			100mA:	±35ppm
			1A:	±110ppm
Resistance Calibrator	Fluke 5450A	Resistance**	1.9Ω:	±65ppm (±460ppm)
			19Ω:	±23ppm (±280ppm)
			190Ω:	±10.5ppm (±230ppm)
			1.9kΩ:	±8ppm (±200ppm)
			19kΩ:	±7.5ppm (±195ppm)
			190kΩ:	±8.5ppm (±200ppm)
			1.9MΩ:	±11.5ppm (±180ppm)
			19MΩ:	±30ppm (±635ppm)
Precision Resistor***	Isotec RUG-Z-1R00-0.1	1Ω, ±0.1%, 100W		

* 90-day, full-range accuracy specifications of ranges required for various measurement points.
** 90-day, ±5°C specifications of nominal resistance values shown. Use actual values for tests. Maximum uncertainty of alternate test equipment shown in parentheses.
*** Required for verification of 3A current range. Characterize resistor to ±300ppm or better using recommended DMM before verifying 3A current measurement range.

1Ω resistor characterization

The recommended 1Ω resistor should be characterized to ±300ppm or better before verifying the 3A current measurement range. (You need not characterize the resistor if you are checking only the 3A current source range.) Use the 4-wire ohms function of the DMM recommended in Table 1-1 to measure the resistance value, and then use that measured value to calculate the current during the 3A current measurement range test procedure.

Verification limits

The verification limits stated in this section have been calculated using only the Model 2420 one-year accuracy specifications, and they do not include test equipment uncertainty. If a particular measurement falls outside the allowable range, recalculate new limits based on Model 2420 specifications and corresponding test equipment specifications.

Example limits calculation

As an example of how verification limits are calculated, assume you are testing the 20V DC output range using a 20V output value. Using the Model 2420 20V range one-year accuracy specification of ±(0.02% of output + 2.4mV offset), the calculated output limits are:

Output limits = 20V ± [(20V × 0.02%) + 2.4mV]
Output limits = 20V ± (0.004 + 0.0024)
Output limits = 20V ± 0.0064V
Output limits = 19.9936V to 20.0064V

Resistance limits calculation

When verifying the resistance measurement accuracy, it will probably be necessary to recalculate resistance limits based on the actual calibrator resistance values. You can calculate resistance reading limits in the same manner described above, but be sure to use the actual calibrator resistance values and the Model 2420 normal accuracy specifications for your calculations.

As an example, assume you are testing the 20kΩ range, and that the actual value of the nominal 19kΩ calibrator resistor is 19.01kΩ. Using the Model 2420 20kΩ range one-year normal accuracy specifications of ±(0.063% of reading + 3Ω), the recalculated reading limits are:

Reading limits = 19.01kΩ ± [(19.01kΩ × 0.063%) + 3Ω]
Reading limits = 19.01kΩ ±15Ω
Reading limits = 18.9950kΩ to 19.0250kΩ

Restoring factory defaults

Before performing the verification procedures, restore the instrument to its factory front panel (bench) defaults as follows:

1. Press the MENU key. The instrument will display the following prompt:
   MAIN MENU
   SAVESETUP COMMUNICATION CAL ▶
2. Select SAVESETUP, and then press ENTER. The unit then displays:
   SAVESETUP MENU
   GLOBAL SOURCE-MEMORY
3. Select GLOBAL, and then press ENTER. The unit then displays:
   GLOBAL SETUP MENU
   SAVE RESTORE POWERON RESET
4. Select RESET, and then press ENTER. The unit displays:
   RESET ORIGINAL DFLTS
   BENCH GPIB
5. Select BENCH, and then press ENTER. The unit then displays:
   RESETTING INSTRUMENT
   ENTER to confirm; EXIT to abort
6. Press ENTER to restore bench defaults, and note the unit displays the following:
   RESET COMPLETE
   BENCH defaults are now restored ▶
   ◀ Press ENTER to continue
7. Press ENTER then EXIT as necessary to return to normal display.

Performing the verification test procedures

Test summary

- DC voltage output accuracy
- DC voltage measurement accuracy
- DC current output accuracy
- DC current measurement accuracy
- Resistance measurement accuracy

If the Model 2420 is not within specifications and not under warranty, see the calibration procedures in Section 2 for information on calibrating the unit.

Test considerations

When performing the verification procedures:

- Be sure to restore factory front panel defaults as previously outlined.
- Make sure that the test equipment is properly warmed up and connected to the Model 2420 INPUT/OUTPUT jacks. Also be sure that the front panel jacks are selected with the TERMINALS key.
- Make sure the Model 2420 is set to the correct source range (see below).
- Be sure that the Model 2420 output is turned on before making measurements.
- Be sure the test equipment is set up for the proper function and range.
- Allow the Model 2420 output signal to settle before making a measurement.
- Do not connect test equipment to the Model 2420 through a scanner, multiplexer, or other switching equipment.

WARNING **The maximum common-mode voltage (voltage between LO and chassis ground) is 250V peak. Exceeding this value may cause a breakdown in insulation, creating a shock hazard.**

CAUTION **The maximum voltage between INPUT/OUTPUT HI and LO or 4-WIRE SENSE HI and LO is 75V peak. The maximum voltage between INPUT/OUTPUT HI and 4-WIRE SENSE HI or between INPUT/OUTPUT LO and 4-WIRE SENSE LO is 5V. Exceeding these voltage values may result in instrument damage.**

Setting the source range and output value

Before testing each verification point, you must properly set the source range and output value as outlined below.

1. Press either the SOURCE V or SOURCE I key to select the appropriate source function.
2. Press the EDIT key as required to select the source display field. Note that the cursor will flash in the source field while its value is being edited.
3. With the cursor in the source display field flashing, set the source range to the lowest possible range for the value to be sourced using the up or down RANGE key. For example, you should use the 20V source range to output a 20V source value. With a 20V source value and the 20V range selected, the source field display will appear as follows:

   Vsrc:+20.0000 V
4. With the source field cursor flashing, set the source output to the required value using either:
   - The SOURCE adjustment and left and right arrow keys.
   - The numeric keys.
5. Note that the source output value will be updated immediately; you need not press ENTER when setting the source value.

Setting the measurement range

When simultaneously sourcing and measuring either voltage or current, the measure range is coupled to the source range, and you cannot independently control the measure range. Thus, it is not necessary for you to set the measure range when testing voltage or current measurement accuracy.

Compliance considerations

Compliance limits

When sourcing voltage, you can set the SourceMeter to limit current from 10nA to 3.15A. Conversely, when sourcing current, you can set the SourceMeter to limit voltage from 0.2mV to 63V. The SourceMeter output will not exceed the programmed compliance limit.

Types of compliance

There are two types of compliance that can occur: "real" and "range." Depending on which value is lower, the output will clamp at either the displayed compliance setting ("real") or at the maximum measurement range reading ("range").

The "real" compliance condition can occur when the compliance setting is less than the highest possible reading of the measurement range. When in compliance, the source output clamps at the displayed compliance value. For example, if the compliance voltage is set to 1V and the measurement range is 2V, the output voltage will clamp (limit) at 1V.

"Range" compliance can occur when the compliance setting is higher than the possible reading of the selected measurement range. When in compliance, the source output clamps at the maximum measurement range reading (not the compliance value). For example, if the compliance voltage is set to 1V and the measurement range is 200mV, the output voltage will clamp (limit) at 210mV.

Maximum compliance values

The maximum compliance values for the measurement ranges are summarized in Table 1-2.

Table 1-2
Maximum compliance values

Measurement range	Maximum compliance value
200mV	210mV
2V	2.1V
20V	21V
60V	63V
10µA	10.5µA
100µA	105 µA
1mA	1.05mA
10mA	10.5mA
100mA	105mA
1A	1.05A
3A	3.15A

When the SourceMeter goes into compliance, the "Cmpl" label or the units label (i.e., "mA") for the compliance display will flash.

Determining compliance limit

The relationships to determine which compliance is in effect are summarized as follows. They assume that the measurement function is the same as the compliance function.

- Compliance Setting < Measurement Range = Real Compliance
- Measurement Range < Compliance Setting = Range Compliance

You can determine the compliance that is in effect by comparing the displayed compliance setting to the present measurement range. If the compliance setting is lower than the maximum possible reading on the present measurement range, the compliance setting is the compliance limit. If the compliance setting is higher than the measurement range, the maximum reading on that measurement range is the compliance limit

Taking the SourceMeter out of compliance

Verification measurements should not be made when the SourceMeter is in compliance. For purposes of the verification tests, the SourceMeter can be taken out of compliance by going into the edit mode and increasing the compliance limit.

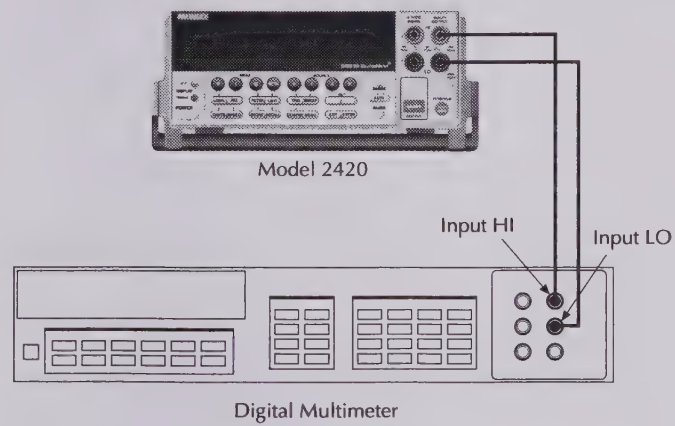
NOTE *Do not take the unit out of compliance by decreasing the source value or changing the range. Always use the recommended range and source settings when performing the verification tests.*

Output voltage accuracy

Follow the steps below to verify that Model 2420 output voltage accuracy is within specified limits. This test involves setting the output voltage to each full-range value and measuring the voltages with a precision digital multimeter.

1. With the power off, connect the digital multimeter to the Model 2420 INPUT/OUTPUT jacks, as shown in Figure 1-1.

Figure 1-1
Connections for voltage verification tests



2. Select the multimeter DC volts measuring function.
3. Set the voltage source protection to NONE. To do so, press CONFIG then SOURCE V to access the CONFIGURE V-SOURCE menu. Select PROTECTION, and set the voltage source protection limit to NONE.
4. Press the Model 2420 SOURCE V key to source voltage, and make sure the source output is turned on.
5. Verify output voltage accuracy for each of the voltages listed in Table 1-3. For each test point:
   - Select the correct source range.
   - Set the Model 2420 output voltage to the indicated value.
   - Verify that the multimeter reading is within the limits given in the table.
6. Repeat the procedure for negative output voltages with the same magnitudes as those listed in Table 1-3.
7. Repeat the entire procedure using the rear panel INPUT/OUTPUT jacks. Be sure to select the rear panel jacks with the front panel TERMINALS key.

Table 1-3
Output voltage accuracy limits

Model 2420 source range	Model 2420 output voltage setting	Output voltage limits (1 year, 18°C-28°C)
200mV	200.000mV	199.360 to 200.640mV
2V	2.00000V	1.99900 to 2.00100V
20V	20.0000V	19.9936 to 20.0064V
60V	60.0000V	59.9808 to 60.0192V

Voltage measurement accuracy

Follow the steps below to verify that Model 2420 voltage measurement accuracy is within specified limits. The test involves setting the source voltage to full-range values, as measured by a precision digital multimeter, and then verifying that the Model 2420 voltage readings are within required limits.

1. With the power off, connect the digital multimeter to the Model 2420 INPUT/OUTPUT jacks , as shown in Figure 1-1.
2. Select the multimeter DC volts function.
3. Set the voltage source protection to NONE. To do so, press CONFIG then SOURCE V to access the CONFIGURE V-SOURCE menu. Select PROTECTION, and set the voltage source protection limit to NONE.
4. Set the Model 2420 to both source and measure voltage by pressing the SOURCE V and MEAS V keys, and make sure the source output is turned on.
5. Verify output voltage accuracy for each of the voltages listed in Table 1-4. For each test point:
   - Select the correct source range.
   - Set the Model 2420 output voltage to the indicated value as measured by the digital multimeter.
   - Verify that the Model 2420 voltage reading is within the limits given in the table.

NOTE *It may not be possible to set the voltage source to the specified value. Use the closest possible setting, and modify reading limits accordingly.*

6. Repeat the procedure for negative source voltages with the same magnitudes as those listed in Table 1-4.
7. Repeat the entire procedure using the rear panel INPUT/OUTPUT jacks. Be sure to select the rear panel jacks with the front panel TERMINALS key.

Table 1-4
Voltage measurement accuracy limits

Model 2420 source and measure range*	Source voltage*	Model 2420 voltage reading limits (1 year, 18°C-28°C)
200mV	200.000mV	199.676 to 200.324mV
2V	2.00000V	1.99946 to 2.00054V
20V	20.0000V	19.9960 to 20.0040V
60V	60.0000V	59.9880 to 60.0120V

*Measure range coupled to source range when simultaneously sourcing and measuring voltage.

**As measured by precision digital multimeter. Use closest possible value, and modify reading limits accordingly if necessary.

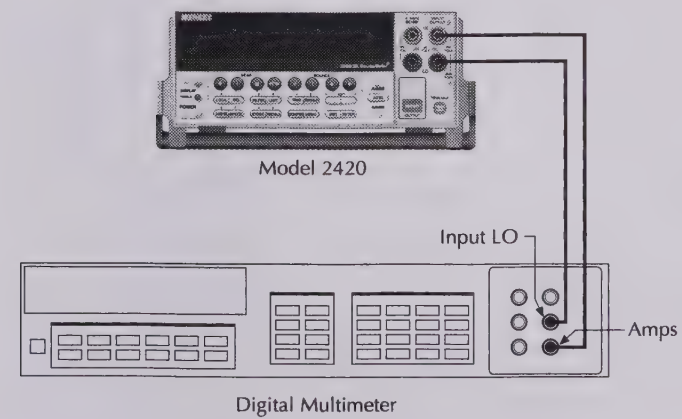
Output current accuracy

Follow the steps below to verify that Model 2420 output current accuracy is within specified limits. The test involves setting the output current to each full-range value and measuring the currents with a precision digital multimeter.

10μA to 1A range accuracy

1. With the power off, connect the digital multimeter to the Model 2420 INPUT/OUTPUT jacks, as shown in Figure 1-2.

Figure 1-2
Connections for 10μA to 1A range current verification tests



2. Select the multimeter DC current measuring function.
3. Press the Model 2420 SOURCE I key to source current, and make sure the source output is turned on.

4. Verify output current accuracy for the 10μA-1A range currents listed in Table 1-5. For each test point:
   - Select the correct source range.
   - Set the Model 2420 output current to the correct value.
   - Verify that the multimeter reading is within the limits given in the table.
5. Repeat the procedure for negative output currents with the same magnitudes as those listed in Table 1-5.
6. Repeat the entire procedure using the rear panel INPUT/OUTPUT jacks. Be sure to select the rear panel jacks with the front panel TERMINALS key.

3A range accuracy

1. With the power off, connect the digital multimeter and the 1Ω resistor to the Model 2420 INPUT/OUTPUT jacks, as shown in Figure 1-3.

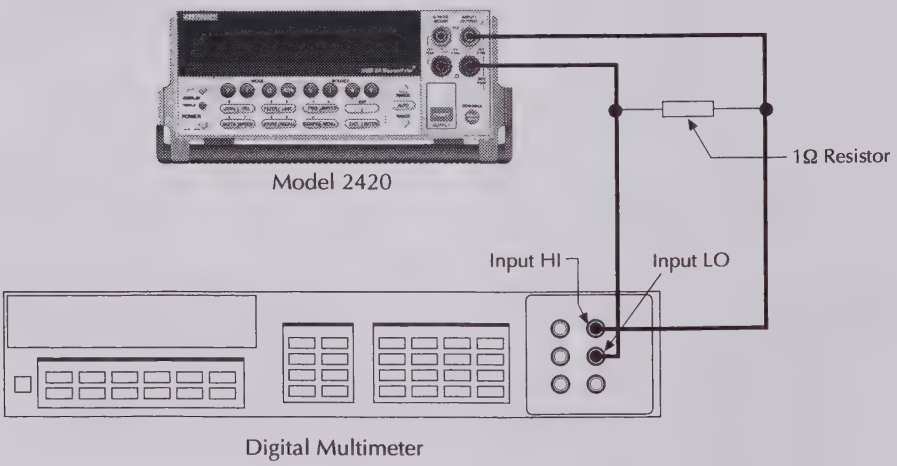


Figure 1-3
Connections for 3A range current verification tests

2. Select the multimeter DC volts measuring function.
3. Press the Model 2420 SOURCE I key to source current, and make sure the source output is turned on.
4. Verify output current accuracy for the 3A range. Be sure to:
   - Select the 3A source range.
   - Set the Model 2420 output current to the correct 3A output value.
   - Verify that the multimeter reading is within the 3A range limits given in Table 1-5.

   (Since the value of the 1Ω resistor value is assumed to be the same as its nominal value, the DMM voltage reading is the same as the sourced current.)
5. Repeat the procedure for a negative 3A current output value.
6. Repeat the entire procedure using the rear panel INPUT/OUTPUT jacks. Be sure to select the rear panel jacks with the front panel TERMINALS key.

Table 1-5
Output current accuracy limits

Model 2420 source range	Model 2420 output current setting	Output current limits (1 year, 18°C-28°C)
10μA	10.0000μA	9.9947 to 10.0053μA
100μA	100.000μA	99.949 to 100.051μA
1mA	1.00000mA	0.99946 to 1.00054mA
10mA	10.0000mA	9.9935 to 10.0065mA
100mA	100.000mA	99.914 to 100.086mA
1A	1.00000A	0.99843 to 1.00157A
3A*	3.00000A	2.99553 to 3.00447A

* See separate procedure for 3A range. DMM voltage reading is same as sourced current.

Current measurement accuracy

Follow the steps below to verify that Model 2420 current measurement accuracy is within specified limits. The procedure involves applying accurate currents from the Model 2420 current source and then verifying that Model 2420 current measurements are within required limits.

10μA to 1A range accuracy

1. With the power off, connect the digital multimeter to the Model 2420 INPUT/OUTPUT jacks, as shown in Figure 1-2.
2. Select the multimeter DC current function.
3. Set the Model 2420 to both source and measure current by pressing the SOURCE I and MEAS I keys, and make sure the source output is turned on.
4. Verify measure current accuracy for the 10μA-1A range currents listed in Table 1-6. For each measurement:
   - Select the correct source range.
   - Set the Model 2420 source output to the correct value as measured by the digital multimeter.
   - Verify that the Model 2420 current reading is within the limits given in the table.

NOTE *It may not be possible to set the current source to the specified value. Use the closest possible setting, and modify reading limits accordingly.*

5. Repeat the procedure for negative calibrator currents with the same magnitudes as those listed in Table 1-6.
6. Repeat the entire procedure using the rear panel INPUT/OUTPUT jacks. Be sure to select the rear panel jacks with the front panel TERMINALS key.

3A range accuracy

NOTE *The 1Ω resistor should be characterized to within ±300ppm before verifying the 3A current measurement range. Use the 4-wire ohms function of the DMM to measure the resistance value, and then use that measured value to calculate the current during the measurement procedure.*

1. With the power off, connect the 1Ω resistor and digital multimeter to the Model 2420 INPUT/OUTPUT jacks, as shown in Figure 1-3.
2. Select the multimeter DC volts function.
3. Set the Model 2420 to both source and measure current by pressing the SOURCE I and MEAS I keys, and make sure the source output is turned on.
4. Verify measurement current accuracy for the 3A range as follows:
   - Select the 3A source range.
   - Set the Model 2420 source output to the correct 3A value as measured by the digital multimeter.
   - Note the DMM voltage reading, and then calculate the current from the voltage reading and characterized 1Ω resistance value as I = V/R, where V is the DMM voltage reading and R is the characterized resistance value.
   - Verify that the Model 2420 current reading is within the 3A limits given in the Table 1-6.

NOTE *It may not be possible to set the current source to the specified 3A value. Use the closest possible setting, and modify reading limits accordingly.*

5. Repeat the procedure for a negative 3A current.
6. Repeat the procedure using the rear panel INPUT/OUTPUT jacks. Be sure to select the rear panel jacks with the front panel TERMINALS key.

Table 1-6
Current measurement accuracy limits

Model 2420 source and measure range*	Source current**	Model 2420 current reading limits (1 year, 18°C-28°C)
10μA	10.00000μA	9.9966 to 10.0034μA
100μA	100.000μA	99.969 to 100.031μA
1mA	1.00000mA	0.99967 to 1.00033mA
10mA	10.0000mA	9.9959 to 10.0041mA
100mA	100.000mA	99.939 to 100.061mA
1A	1.00000A	0.99883 to 1.00117A
3A	3.00000A	2.99673 to 3.00327A***

*Measure range coupled to source range when simultaneously sourcing and measuring current.
**As measured by precision digital multimeter. Use closest possible value, and modify reading limits accordingly if necessary.
***Current calculated as follows: I = V/R, where V is the DMM voltage reading, and R is the characterized value of the 1Ω resistor.

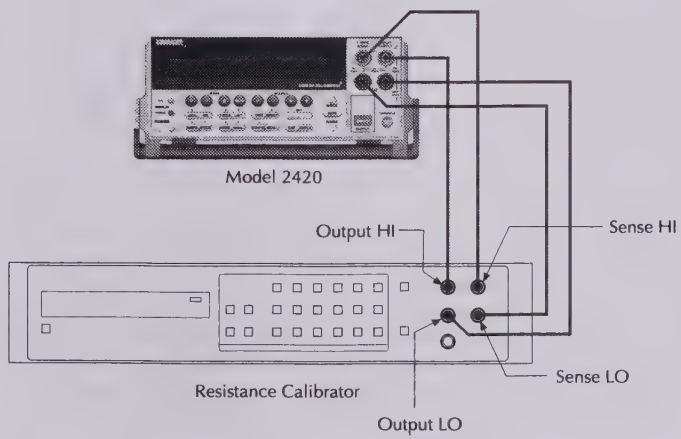
Resistance measurement accuracy

Use the following steps to verify that Model 2420 resistance measurement accuracy is within specified limits. This procedure involves applying accurate resistances from a resistance calibrator and then verifying that Model 2420 resistance measurements are within required limits.

CAUTION **Before testing the 2Ω and 20Ω ranges make sure your resistance calibrator can safely handle the default test currents for those ranges (see Model 2420 and calibrator specifications). If not, use the CONFIG OHMS menu to select the MANUAL source mode, then set the source current to an appropriate safe value. When using the manual source mode, total resistance reading uncertainty includes both Source I and Measure V uncertainty (see specifications), and calculated reading limits should take the additional uncertainty into account.**

1. With the power off, connect the resistance calibrator to the Model 2420 INPUT/OUTPUT and 4-WIRE SENSE jacks, as shown in Figure 1-4. Be sure to use the 4-wire connections as shown.

Figure 1-4
Connections for resistance accuracy verification



2. Select the resistance calibrator external sense mode.
3. Configure the Model 2420 ohms function for the 4-wire sense mode as follows:
   - Press CONFIG then MEAS Ω. The instrument will display the following:
     CONFIG OHMS
     SOURCE SENSE-MODE GUARD
   - Select SENSE-MODE, and then press ENTER. The following will be displayed:
     SENSE-MODE
     2-WIRE 4-WIRE
   - Select 4-WIRE, and then press ENTER.
   - Press EXIT to return to normal display.

4. Press MEAS Ω to select the ohms measurement function, and make sure the source output is turned on.
5. Verify ohms measurement accuracy for each of the resistance values listed in Table 1-7. For each measurement:
   - Set the resistance calibrator output to the nominal resistance or closest available value.

NOTE *It may not be possible to set the resistance calibrator to the specified value. Use the closest possible setting, and modify reading limits accordingly.*

   - Select the appropriate ohms measurement range with the RANGE keys.
   - Verify that the Model 2420 resistance reading is within the limits given in the table.
6. Repeat the entire procedure using the rear panel INPUT/OUTPUT and 4-WIRE SENSE jacks. Be sure to select the rear panel jacks with the front panel TERMINALS key.

Table 1-7
Ohms measurement accuracy limits

Model 2420 range	Calibrator resistance*	Model 2420 resistance reading limits** (1 year, 18°C-28°C)
2Ω	1.9Ω	1.89649 to 1.90351Ω
20Ω	19Ω	18.9784 to 19.0216Ω
200Ω	190Ω	189.824 to 190.176Ω
2kΩ	1.9kΩ	1.89845 to 1.90155kΩ
20kΩ	19kΩ	18.9850 to 19.0150kΩ
200kΩ	190kΩ	189.847 to 190.153kΩ
2MΩ	1.9MΩ	1.89861 to 1.90139MΩ
20MΩ	19MΩ	18.9517 to 19.0483MΩ

*Nominal resistance value.
**Reading limits based on Model 2420 normal accuracy specifications and nominal resistance values. If actual resistance values differ from nominal values shown, recalculate reading limits using actual calibrator resistance values and Model 2420 normal accuracy specifications. See Verification limits earlier in this section for details.

2
Calibration

Introduction

Use the procedures in this section to calibrate the Model 2420. These procedures require accurate test equipment to measure precise DC voltages and currents. Calibration can be performed either from the front panel or by sending SCPI calibration commands over the IEEE-488 bus or RS-232 port with the aid of a computer.

WARNING **This information in this section is intended for qualified service personnel only. Do not attempt these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages.**

Environmental conditions

Temperature and relative humidity

Conduct the calibration procedures at an ambient temperature of 18-28°C (65-82°F) with relative humidity of less than 70% unless otherwise noted.

Warm-up period

Allow the Model 2420 to warm up for at least one hour before performing calibration.

If the instrument has been subjected to temperature extremes (those outside the ranges stated above), allow additional time for the instrument's internal temperature to stabilize. Typically, allow one extra hour to stabilize a unit that is 10°C (18°F) outside the specified temperature range.

Also, allow the test equipment to warm up for the minimum time specified by the manufacturer.

Line power

The Model 2420 requires a line voltage of 90 to 250V at line frequency of 50 to 60Hz. The instrument must be calibrated while operating from a line voltage within this range.

Calibration considerations

When performing the calibration procedures:

- Make sure that the test equipment is properly warmed up and connected to the Model 2420 front panel INPUT/OUTPUT jacks. Also be certain that the front panel jacks are selected with the TERMINALS switch.
- Always allow the source signal to settle before calibrating each point.
- Do not connect test equipment to the Model 2420 through a scanner or other switching equipment.
- If an error occurs during calibration, the Model 2420 will generate an appropriate error message. See Appendix B for more information.

WARNING **The maximum common-mode voltage (voltage between LO and chassis ground) is 250V peak. Exceeding this value may cause a breakdown in insulation, creating a shock hazard.**

CAUTION **The maximum voltage between INPUT/OUTPUT HI and LO or 4-WIRE SENSE HI and LO is 75V peak. The maximum voltage between INPUT/OUTPUT HI and 4-WIRE SENSE HI or between INPUT/OUTPUT LO and 4-WIRE SENSE LO is 5V. Exceeding these voltage values may result in instrument damage.**

Calibration cycle

Perform calibration at least once a year to ensure the unit meets or exceeds its specifications.

Recommended calibration equipment

Table 2-1 lists the recommended equipment for the calibration procedures. You can use alternate equipment as long that equipment has specifications at least as good as those listed in the table. For optimum calibration accuracy, test equipment specifications should be at least four times better than corresponding Model 2420 specifications.

Table 2-1
Recommended calibration equipment

Description	Manufacturer/Model	Specifications		
Digital Multimeter	Hewlett Packard HP3458A	DC Voltage*	1V:	±5.6ppm
			10V:	±4.3ppm
			100V	±6.3ppm
		DC Current*	10µA:	±25ppm
			100µA:	±23ppm
			1mA:	±20ppm
			10mA:	±20ppm
			100mA:	±35ppm
			1A:	±110ppm
Precision Resistor**	Isotec RUG-Z-1R00-0.1	1Ω, ±0.1%, 100W		

*90-day, full-range accuracy specifications of ranges required for various measurement points.
** Necessary for calibration of 3A current range. Resistor must be characterized to ±300ppm or better using recommended DMM before calibrating 3A range.

1Ω resistor characterization

The 1Ω resistor must be characterized to ±300ppm or better before calibrating the 3A current range. Use the 4-wire ohms function of the DMM recommended in Table 1-1 to measure the resistance value, and then use that measured value to calculate the current during the 3A current range calibration procedure.

Unlocking calibration

Before performing calibration, you must first unlock calibration by entering or sending the calibration password as explained in the following paragraphs.

Unlocking calibration from the front panel

1. Press the MENU key, and then choose CAL, and press ENTER. The instrument will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES
   ◀ SAVE LOCK CHANGE-PASSWORD
2. Select UNLOCK, and then press ENTER. The instrument will display the following:
   PASSWORD:
   Use ◀,▶,▲,▼, ENTER or EXIT.
3. Use the up and down RANGE keys to select the letter or number, and use the left and right arrow keys to choose the position. (Press down RANGE for letters; up RANGE for numbers.) Enter the present password on the display. (Front panel default: 002420.)

4. Once the correct password is displayed, press the ENTER key. If the password was correctly entered, the following message will be displayed:
   CALIBRATION UNLOCKED
   Calibration can now be executed.
5. Press EXIT to return to normal display. Calibration will be unlocked and assume the states summarized in Table 2-2. Attempts to change any of the settings listed below with calibration unlocked will result in an error +510, "Not permitted with cal un-locked."

NOTE *With calibration unlocked, the sense function and range track the source function and range. That is, when :SOUR:FUNC is set to VOLT, the :SENS:FUNC setting will be 'VOLT:DC'. When :SOUR:FUNC is set to CURR, the :SENS:FUNC setting will be 'CURR:DC'. A similar command coupling exists for :SOUR:VOLT:RANG/ :SENS:VOLT:RANG and SOUR:CURR:RANG:SENS:CURR:RANG.*

Table 2-2
Calibration unlocked states

Mode	State	Equivalent remote command
Concurrent Functions	OFF	:SENS:FUNC:CONC OFF
Sense Function	Source	:SENS:FUNC <source_ function>
Sense Volts NPLC	1.0	:SENS:VOLT:NPLC 1.0
Sense Volts Range	Source V	:SENS:VOLT:RANG <source_V_range>
Sense Current NPLC	1.0	:SENS:CURR:NPLC 1.0
Sense Current Range	Source I	:SENS:CURR:RANG <source_ I_ range>
Filter Count	10	:SENS:AVER:COUN 10
Filter Control	REPEAT	:SENS:AVER:TCON REPeat
Filter Averaging	ON	:SENS:AVER:STAT ON
Source V Mode	FIXED	:SOUR:VOLT:MODE FIXED
Volts Autorange	OFF	:SOUR:VOLT:RANG:AUTO OFF
Source I Mode	FIXED	:SOUR:CURR:MODE FIXED
Current Autorange	OFF	:SOUR:CURR:RANG:AUTO OFF
Autozero	ON	:SYST:AZERO ON
Trigger Arm Count	1	:ARM:COUNT 1
Trigger Arm Source	Immediate	:ARM:SOUR IMMediate
Trigger Count	1	:TRIG:COUNT 1
Trigger Source	Immediate	:TRIG:SOUR IMMediate

Unlocking calibration by remote

To unlock calibration via remote, send the following command:

:CAL:PROT:CODE '<password>'

For example, the following command uses the default password:

:CAL:PROT:CODE 'KI002420'

Changing the password

The default password may be changed from the front panel or via remote as discussed below.

Changing the password from the front panel

Follow the steps below to change the password from the front panel:

1. Press the MENU key, then choose CAL and press ENTER. The instrument will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶
   ◀ SAVE LOCK CHANGE-PASSWORD
2. Select UNLOCK, then enter the password. (Default: 002420.)
3. Select CHANGE-PASSWORD, and then press ENTER. The instrument will display the following:
   New Pwd: 002420
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
4. Using the range keys, and the left and right arrow keys, enter the new password on the display.
5. Once the desired password is displayed, press the ENTER key to store the new password.

Changing the password by remote

To change the calibration password by remote, first send the present password, and then send the new password. For example, the following command sequence changes the password from the 'KI002420' remote default to 'KI_CAL':

```
:CAL:PROT:CODE 'KI002420'
:CAL:PROT:CODE 'KI_CAL'
```

You can use any combination of letters and numbers up to a maximum of eight characters.

NOTE *If you change the first two characters of the password to something other than "KI", you will not be able to unlock calibration from the front panel.*

Resetting the calibration password

If you lose the calibration password, you can unlock calibration by shorting together the CAL pads, which are located on the display board. Doing so will also reset the password to the factory default (KI002420).

See Section 5 for details on disassembling the unit to access the CAL pads. Refer to the display board component layout drawing at the end of Section 6 for the location of the CAL pads.

Viewing calibration dates and calibration count

When calibration is locked, only the UNLOCK and VIEW-DATES selections will be accessible in the calibration menu. To view calibration dates and calibration count at any time:

1. From normal display, press MENU, select CAL, and then press ENTER. The unit will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES
2. Select VIEW-DATES, and then press ENTER. The Model 2420 will display the next and last calibration dates and the calibration count as in the following example:
   NEXT CAL: 02/15/98
   Last calibration: 02/15/97 Count: 0001

Calibration errors

The Model 2420 checks for errors after each calibration step, minimizing the possibility that improper calibration may occur due to operator error.

Front panel error reporting

If an error is detected during comprehensive calibration, the instrument will display an appropriate error message (see Appendix B). The unit will then prompt you to repeat the calibration step that caused the error.

Remote error reporting

You can detect errors while in remote by testing the state of EAV (Error Available) bit (bit 2) in the status byte. (Use the *STB? query to request the status byte.) Query the instrument for the type of error by using the appropriate :SYST:ERR? query. The Model 2420 will respond with the error number and a text message describing the nature of the error. See Appendix B for details.

Front panel calibration

The front panel calibration procedure described below calibrates all ranges of both the current and voltage source and measure functions. Note that each range is separately calibrated by repeating the entire procedure for each range.

Step 1: Prepare the Model 2420 for calibration

1. Turn on the Model 2420 and the digital multimeter, and allow them to warm up for at least one hour before performing calibration.

2. Press the MENU key, then choose CAL and press ENTER. Select UNLOCK, and then press ENTER. The instrument will display the following:
   PASSWORD:
   Use ◀, ▶, ▲, ▼, ENTER or EXIT.
3. Use the up and down range keys to select the letter or number, and use the left and right arrow keys to choose the position. Enter the present password on the display. (Front panel default: 002420.) Press ENTER to complete the process.
4. Press EXIT to return to normal display. Instrument operating states will be set as summarized in Table 2-2.

Step 2: Voltage calibration

Perform the steps below for each voltage range, using Table 2-3 as a guide.

1. Connect the Model 2420 to the digital multimeter, as shown in Figure 2-1. Select the multimeter DC volts measurement function.

NOTE *The 2-wire connections shown assume that remote sensing is not used. Remote sensing may be used, if desired, but it is not essential when using the recommended digital multimeter.*

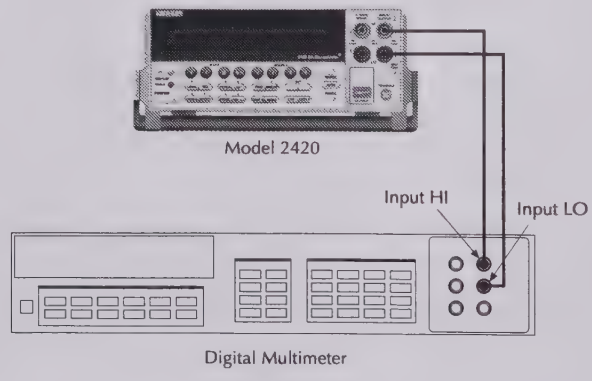


Figure 2-1
Voltage calibration test connections

2. From normal display, press the SOURCE V key.
3. Press the EDIT key to select the source field (cursor flashing in source display field), and then use the down RANGE key to select the 200mV source range.
4. From normal display, press MENU.
5. Select CAL, and then press ENTER. The unit will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶
   ◀ SAVE LOCK CHANGE-PASSWORD
6. Select EXECUTE, and then press ENTER. The instrument will display the following message:
   V-CAL
   Press ENTER to Output +200.00mV

7. Press ENTER. The Model 2420 will source +200mV and simultaneously display the following:
   DMM RDG: +200.0000mV
   Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
8. Note and record the DMM reading, and then adjust the Model 2420 display to agree exactly with the actual DMM reading. Use the up and down arrow keys to select the digit value, and use the left and right arrow keys to choose the digit position (or use the number keys, 0-9, +/-). Note that the display adjustment range is within ±10% of the present range.
9. After adjusting the display to agree with the DMM reading, press ENTER. The instrument will then display the following:
   V-CAL
   Press ENTER to Output +000.00mV
10. Press ENTER. The Model 2420 will source 0mV and at the same time display the following:
    DMM RDG: +000.0000mV
    Use ◀, ▶, ▲, ▼,ENTER, or EXIT.
11. Note and record the DMM reading, and then adjust the Model 2420 display to agree with the actual DMM reading. Note that the display value adjustment limits are within ±1% of the present range.
12. After adjusting the display value to agree with the DMM reading, press ENTER. The unit will then display the following:
    V-CAL
    Press ENTER to Output -200.00mV
13. Press ENTER. The Model 2420 will source -200mV and display the following:
    DMM RDG: -200.0000mV
    Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
14. Note and record the DMM reading, and then adjust the Model 2420 display to agree with the DMM reading. Again, the maximum display adjustment is within ± 10% of the present range.
15. After adjusting the display value to agree with the DMM reading, press ENTER and note that the instrument displays:
    V-CAL
    Press ENTER to Output -000.00mV
16. Press ENTER The Model 2420 will source -0mV and simultaneously display the following:
    DMM RDG: +000.0000mV
    Use ◀, ▶, ▲, ▼, ENTER or EXIT.
17. Note and record the DMM reading, and then adjust the display to agree with the DMM reading. Once again, the maximum adjustment is within ±1% of the present range.
18. After adjusting the display to agree with the DMM reading, press ENTER to complete calibration of the present range.
19. Press EXIT to return to normal display, and then select the 2V source range. Repeat steps 2 through 18 for the 2V range.
20. After calibrating the 2V range, repeat the entire procedure for the 20V and 60V ranges using Table 2-3 as a guide. Be sure to select the appropriate source range with the EDIT and RANGE keys before calibrating each range.
21. Press EXIT as necessary to return to normal display.

Table 2-3
Front panel voltage calibration

Source range*	Source voltage	Multimeter voltage reading**
0.2V	+200.00mV	_____ mV
	+000.00mV	_____ mV
	-200.00mV	_____ mV
	-000.00mV	_____ mV
2V	+2.0000V	_____ V
	+0.0000V	_____ V
	-2.0000V	_____ V
	-0.0000V	_____ V
20V	+20.000V	_____ V
	+00.000V	_____ V
	-20.000V	_____ V
	-00.000V	_____ V
60V	+60.000V	_____ V
	+00.000V	_____ V
	-60.000V	_____ V
	-00.000V	_____ V

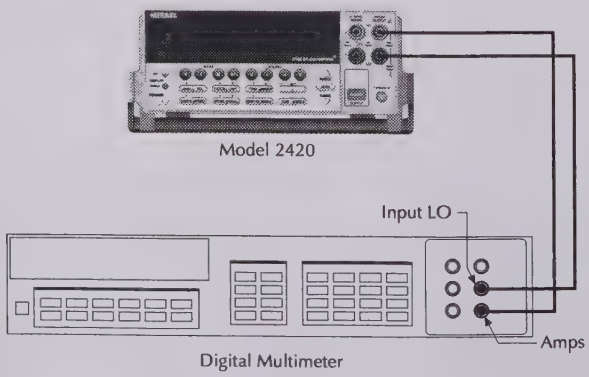
*Use EDIT and RANGE keys to select source range.
**Multimeter reading used in corresponding calibration step. See procedure.

Step 3: Current calibration

Perform the steps below for each current range, using Table 2-4 as a guide.

1. Connect the Model 2420 to the digital multimeter, as shown in Figure 2-2. Select the multimeter DC current measurement function.

Figure 2-2
10μA to 1A range current calibration test connections



2. From normal display, press the SOURCE I key.
3. Press the EDIT key to select the source display field, and then use the down RANGE key to select the 10μA source range.
4. From normal display, press MENU.
5. Select CAL, and then press ENTER. The unit will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶
   ◀ SAVE LOCK CHANGE-PASSWORD
6. Select EXECUTE, and then press ENTER. The instrument will display the following message:
   I-CAL
   Press ENTER to Output +10.000μA
7. Press ENTER. The Model 2420 will source +10μA and simultaneously display the following:
   DMM RDG: +10.00000μA
   Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
8. Note and record the DMM reading, and then adjust the Model 2420 display to agree exactly with the actual DMM reading. Use the up and down arrow keys to select the digit value, and use the left and right arrow keys to choose the digit position (or use the number keys, 0-9, +/-). Note that the display adjustment range is within ±10% of the present range.
9. After adjusting the display to agree with the DMM reading, press ENTER. The instrument will then display the following:
   I-CAL
   Press ENTER to Output +00.000μA
10. Press ENTER. The Model 2420 will source 0mA and at the same time display the following:
    DMM RDG: +00.00000μA
    Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
11. Note and record the DMM reading, and then adjust the Model 2420 display to agree with the actual DMM reading. Note that the display value adjustment limits are within ±1% of the present range.
12. After adjusting the display value to agree with the DMM reading, press ENTER. The unit will then display the following:
    I-CAL
    Press ENTER to Output -10.000μA
13. Press ENTER. The Model 2420 will source -10μA and display the following:
    DMM RDG: -10.00000μA
    Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
14. Note and record the DMM reading, and then adjust the Model 2420 display to agree with the DMM reading. Again, the maximum display adjustment is within ± 10% of the present range.
15. After adjusting the display value to agree with the DMM reading, press ENTER and note that the instrument displays:
    I-CAL
    Press ENTER to Output -00.000μA

16. Press ENTER The Model 2420 will source -0μA and simultaneously display the following:
    DMM RDG: +00.00000μA
    Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
17. Note and record the DMM reading, and then adjust the display to agree with the DMM reading. Once again, the maximum adjustment is within ±1% of the present range.
18. After adjusting the display to agree with the DMM reading, press ENTER to complete calibration of the present range.
19. Press EXIT to return to normal display, and then select the 100μA source range use the EDIT and up RANGE keys. Repeat steps 2 through 18 for the 100μA range.
20. After calibrating the 100μA range, repeat the entire procedure for the 1mA through 1A ranges using Table 2-4 as a guide. Be sure to select the appropriate source range with the EDIT and up RANGE keys before calibrating each range.
21. After calibrating the 1A range, connect the 1Ω characterized resistor and DMM to the Model 2420 INPUT/OUTPUT jacks, as shown in Figure 2-3.
22. Select the DMM DC volts function.
23. Repeat steps 2 through 18 for the 3A range using Table 2-4 as a guide. When entering the DMM reading, use the calculated current as follows: I = V/R, where V is the DMM voltage reading, and R is the characterized value of the 1Ω resistor.

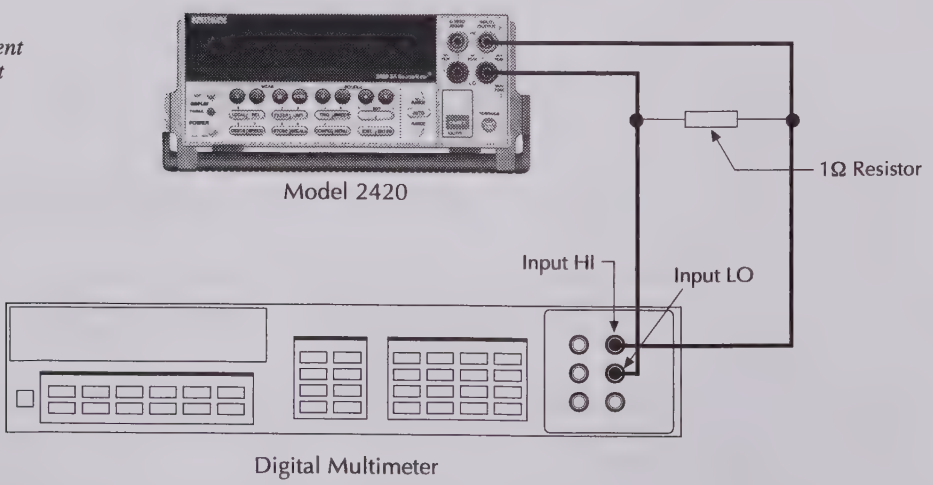


Figure 2-3
3A range current calibration test connections

Table 2-4
Front panel current calibration

Source range*	Source current	Multimeter current reading**
10µA	+10.000µA	_____ µA
	+00.000µA	_____ µA
	-10.000µA	_____ µA
	-00.000µA	_____ µA
100µA	+100.00µA	_____ µA
	+000.00µA	_____ µA
	-100.00µA	_____ µA
	-000.00µA	_____ µA
1mA	+1.0000mA	_____ mA
	+0.0000mA	_____ mA
	-1.0000mA	_____ mA
	-0.0000mA	_____ mA
10mA	+10.000mA	_____ mA
	+00.000mA	_____ mA
	-10.000mA	_____ mA
	-00.000mA	_____ mA
100mA	+100.00mA	_____ mA
	+000.00mA	_____ mA
	-100.00mA	_____ mA
	-000.00mA	_____ mA
1A	+1.0000A	_____ A
	+0.0000A	_____ A
	-1.0000A	_____ A
	-0.0000A	_____ A
3A***	+3.0000A	_____ A
	+0.0000A	_____ A
	-3.0000A	_____ A
	-0.0000A	_____ A

*Use EDIT and RANGE keys to select source range.
**Multimeter reading used in corresponding calibration step. See procedure.
***Current calculated as follows: I = V/R, where V is the DMM reading, and R is the characterized value of the 1Ω resistor.

Step 4: Enter calibration dates and save calibration

NOTE *For temporary calibration without saving new calibration constants, proceed to Step 5: Lock out calibration.*

1. From normal display, press MENU.
2. Select CAL, and then press ENTER. The Model 2420 will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶
   ◀ SAVE LOCK CHANGE-PASSWORD

3. Select SAVE, and then press ENTER. The instrument will display the following message:
   SAVE CAL
   Press ENTER to continue; EXIT to abort calibration sequence.
4. Press ENTER. The unit will prompt you for the calibration date:
   CAL DATE: 2/15/97
   Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
5. Change the displayed date to today's date, and then press the ENTER key. Press ENTER again to confirm the date.
6. The unit will then prompt for the calibration due date:
   NEXT CAL: 2/15/98
   Use ◀, ▶, ▲, ▼, ENTER, or EXIT.
7. Set the calibration due date to the desired value, and then press ENTER. Press ENTER again to confirm the date.
8. Once the calibration dates are entered, calibration is complete, and the following message will be displayed:
   CALIBRATION COMPLETE
   Press ENTER to confirm; EXIT to abort
9. Press ENTER to save the calibration data (or press EXIT to abort without saving calibration data.) The following message will be displayed:
   CALIBRATION SUCCESS
   Press ENTER or EXIT to continue.
10. Press ENTER or EXIT to complete process.

Step 5: Lock out calibration

1. From normal display, press MENU.
2. Select CAL, and then press ENTER. The Model 2420 will display the following:
   CALIBRATION
   UNLOCK EXECUTE VIEW-DATES ▶
   ◀ SAVE LOCK CHANGE-PASSWORD
3. Select LOCK, and then press ENTER. The instrument will display the following message:
   CALIBRATION LOCKED.
   Press ENTER or EXIT to continue.
4. Press ENTER or EXIT to return to normal display.

Remote calibration

Use the following procedure to perform remote calibration by sending SCPI commands over the IEEE-488 bus or RS-232 port. The remote commands and appropriate parameters are separately summarized for each step.

Remote calibration commands

Table 2-5 summarizes remote calibration commands. For a more complete description of these commands, refer to Appendix B.

Table 2-5
Remote calibration command summary

Command	Description
:CALibration	Calibration subsystem.
:PROTected	Cal commands protected by password.
:CODE '<password>'	Unlock cal; changes password if cal is already unlocked. (Default password: KI002420.)
:COUNT?	Query number of times 2420 has been calibrated.
:SAVE	Save calibration data to EEPROM.*
:LOCK	Lock calibration, inhibit SAVE command operation.
:LOCK?	Request cal lock status.
:DATE <y>,<m>,<d>	Program calibration year, month, day.
:DATE?	Query calibration year, month, day.
:NDUE <y>,<m>,<d>	Program calibration due year, month, day.
:NDUE?	Query calibration due year, month, day.
:SENSe <nrf>	Calibrate active measure range. (See Table 2-6 parameters.)
:DATA?	Query measurement cal constants for active range.
:SOURce <nrf>	Calibrate active source range. (See Table 2-7 parameters.)
:DATA?	Query source cal constants for active range.

* Calibration data will not be saved if:

1. Calibration was not unlocked with :CODE command.
2. Invalid data exists. (For example, cal step failed or was aborted.)
3. Incomplete number of cal steps were performed. (For example, omitting a negative full-scale step).
   Ranges that calibrated successfully will be saved if calibration is unlocked. Ranges that failed will not be saved.

Recommended calibration parameters

The maximum calibration command parameter ranges are: 75% to 150% of full scale for positive and negative full scale calibration points; ± zero calibration steps have ±50% of full scale for valid entry ranges. However, for optimum calibration, it is recommended that you use calibration points within the ranges listed in Table 2-6 and Table 2-7. Note that each sense range requires three parameters: zero, negative full scale, and positive full scale. Similarly, each source range requires four parameters: two zero parameters, a positive full-scale parameter, and a negative full-scale parameter.

Table 2-6
Recommended :CALibration:PROTected:SENse parameter ranges

Sense range	First parameter (zero)	Second parameter (negative full scale)	Third parameter (positive full scale)
0.2V	-0.002 to +0.002	-0.18 to -0.22	+0.18 to +0.22
2V	-0.02 to +0.02	-1.8 to -2.2	+1.8 to +2.2
20V	-0.2 to +0.2	-18 to -22	+18 to +22
60V	-0.5 to +0.5	-50 to -65	+50 to +65
10µA	-1E-7 to +1E-7	-9E-6 to -11E-6	+9E-6 to +11E-6
100µA	-1E-6 to +1E-6	-90E-6 to -110E-6	+90E-6 to +110E-6
1mA	-1E-5 to +1E-5	-0.9E-3 to -1.1E-3	+0.9E-3 to +1.1E-3
10mA	-1E-4 to +1E-4	-9E-3 to -11E-3	+9E-3 to +11E-3
100mA	-1E-3 to +1E-3	-90E-3 to -110E-3	+90E-3 to +110E-3
1A	-1E-2 to +1E-2	-0.9 to -1.1	+0.9 to +1.1
3A	-3E-2 to +3E-2	-2.7 to -3.15	+2.7 to +3.15

Note: Parameter steps for each range may be performed in any order, but all three parameter steps for each range must be completed. For optimum calibration, use parameters within recommended limits.

Table 2-7
Recommended :CALibration:PROTected:SOURce parameter ranges

Source range	Second parameter (negative full scale)	Second parameter (negative zero)	Third parameter (positive full scale)	Fourth parameter (positive zero)
0.2V	-0.18 to -0.22	-0.002 to +0.002	+0.18 to +0.22	-0.002 to +0.002
2V	-1.8 to -2.2	-0.02 to +0.02	+1.8 to +2.2	-0.02 to +0.02
20V	-18 to -22	-0.2 to +0.2	+18 to +22	-0.2 to +0.2
60V	-50 to -65	-0.5 to +0.5	+50 to +65	-0.5 to +0.5
10µA	-9E-6 to -11E-6	-1E-7 to +1E-7	+9E-6 to +11E-6	-1E-7 to +1E-7
100µA	-90E-6 to -110E-6	-1E-6 to +1E-6	+90E-6 to +110E-6	-1E-6 to +1E-6
1mA	-0.9E-3 to -1.1E-3	-1E-5 to +1E-5	+0.9E-3 to +1.1E-3	-1E-5 to +1E-5
10mA	-9E-3 to -1E-3	-1E-4 to +1E-4	+9E-3 to +11E-3	-1E-4 to +1E-4
100mA	-90E-3 to -110E-3	-1E-3 to +1E-3	+90E-3 to +110E-3	-1E-3 to +1E-3
1A	-0.9 to -1.1	-1E-2 to +1E-2	+0.9 to +1.1	-1E-2 to +1E-2
3A	-2.7 to -3.15	-3E-2 to +3E-2	+2.7 to +3.15	-3E-2 to +3E-2

Note: Parameter steps for each range may be performed in any order, but all four parameter steps for each range must be completed. For optimum calibration, use parameters within recommended limits.

Remote calibration procedure

Step 1: Prepare the Model 2420 for calibration

1. Connect the Model 2420 to the controller IEEE-488 interface or RS-232 port using a shielded interface cable.
2. Turn on the Model 2420 and the test equipment, and allow them to warm up for at least one hour before performing calibration.
3. If you are using the IEEE-488 interface, make sure the primary address of the Model 2420 is the same as the address specified in the program you will be using to send commands. (Use the MENU key and the COMMUNICATION menu to access the IEEE-488 address.)

Step 2: Voltage calibration

1. Connect the Model 2420 to the digital multimeter (see Figure 2-1), and select the multimeter DC volts function.
2. Send the commands summarized in Table 2-8 in the order listed to initialize voltage calibration. (When the :CAL:PROT:CODE command is sent, the instrument will assume the operating states listed in Table 2-2.)
3. Perform the range calibration steps listed in Table 2-9 for all ranges. For each range:
   - Send the :SOUR:VOLT:RANG command to select the source and sense range being calibrated.. For example, for the 2V range, the following command would be sent
     :SOUR:VOLT:RANG 2
   - Program the source to output the negative full-range value using the :SOUR:VOLT command.
     For example:
     :SOUR:VOLT -2
   - Note and record the multimeter reading.
   - Use the multimeter reading as the parameter for the :CAL:PROT:SOUR and
   - :CAL:PROT:SENS commands. For example, a typical value for the 2V range would be:
     :CAL:PROT:SOUR -1.998
     :CAL:PROT:SENS -1.998
   - Program the voltage source for 0V output using the :SOUR:VOLT 0.0 command.
   - Note the multimeter reading.
   - Send the source and sense calibration commands using the multimeter reading for the parameter. For example:
     :CAL:PROT:SOUR 1E-3
     :CAL:PROT:SENS 1E-3
   - Set the source to the positive full-range value using the :SOUR:VOLT command. For example:
     :SOUR:VOLT 2

- Note and record the multimeter reading.
- Send the source and sense commands using the multimeter reading as the parameter. For example:

  :CAL:PROT:SOUR 1.997
  :CAL:PROT:SENS 1.997
- Send the SOUR:VOLT 0.0 command to set the source voltage to 0V.
- Note and record the multimeter reading.
- Send the :CAL:PROT:SOUR command using the multimeter reading as the command parameter. For example:

  :CAL:PROT:SOUR -1.02E-3

Table 2-8
Voltage calibration initialization commands

Command	Description
*RST	Restore GPIB defaults.
:SOUR:FUNC VOLT	Activate voltage source.
:SENS:CURR:PROT 0.1	Current limit when voltage source is active.
:SENS:CURR:RANG 0.1	Make sure 1A range is not active.
:SOUR:VOLT:PROT MAX	Maximum allowable source voltage.
:SYST:RSEN OFF	Disable remote sensing. *
:CAL:PROT:CODE 'KI002420'	Unlock cal.
:OUTP:STAT ON	Turn source on.

* Remote sensing may be used if desired, but is not essential when using the recommended digital multimeter. To use remote sensing, send :SYST:RSEN ON.

Table 2-9
Voltage range calibration commands

Step	Command/procedure*	Description
1	:SOUR:VOLT:RANGE <Range>	Select source range.
2	:SOUR:VOLT -<Source_value>	Establish negative full-range polarity.
3	Take DMM reading.	Read actual output value.
4	:CAL:PROT:SOUR <DMM_Reading>	Calibrate sense function negative full scale.
5	Check 2420 for errors.	
6	:CAL:PROT:SENS <DMM_Reading>	Calibrate source function negative full scale.
7	Check 2420 for errors.	
8	:SOUR:VOLT 0.0	Set output to 0V.
9	Take DMM reading.	Read actual output value.
10	:CAL:PROT:SOUR <DMM_Reading>	Calibrate sense function negative zero.
11	Check 2420 for errors.	
12	:CAL:PROT:SENS <DMM_Reading>	Calibration source function negative zero.
13	Check 2420 for errors.	
14	:SOUR:VOLT +<Source_value>	Establish positive full-range polarity.
15	Take DMM reading.	Read actual output value
16	:CAL:PROT:SOUR <DMM_Reading>	Calibrate sense function positive full scale.
17	Check 2420 for errors.	
18	:CAL:PROT:SENS <DMM_Reading>	Calibrate source function positive full scale.
19	Check 2420 for errors.	
20	:SOUR:VOLT 0.0	Set output to 0V.
21	Take DMM reading.	Read actual output value.
22	:CAL:PROT:SOUR <DMM_Reading>	Calibrate source positive zero.

*1. Perform complete procedure for each range, where <Range> = 0.2, 2, 20, and 60, and <Source_value> = 0.2, 2, 20, and 60.
2. <DMM_Reading> parameter is multimeter reading from previous step.
3. Use :SYST:ERR? query to check for errors.

Step 3: Current calibration

1. Connect the Model 2420 to the digital multimeter (see Figure 2-2), and select the multimeter DC current function.
2. Send the commands summarized in Table 2-10 in the order listed to initialize current calibration.
3. Calibrate the 10μA to 1A current ranges using the procedure summarized in Table 2-11. For each range:
   - Send the :SOUR:CURR:RANG command to select the source and sense range being calibrated. For example, for the 1mA range, the command is:
     :SOUR:CURR:RANG 1E-3

- Program the source to output the negative full-range value using the :SOUR:CURR command. For example:
  :SOUR:CURR -1E-3
- Note and record the multimeter reading.
- Use the multimeter reading as the parameter for the :CAL:PROT:SOUR and :CAL:PROT:SENS commands. For example, a typical value for the 1mA range would be:

  :CAL:PROT:SOUR -1.025E-3
  :CAL:PROT:SENS -1.025E-3
- Program the current source for 0A output using the :SOUR:CURR 0.0 command.
- Note the multimeter reading.
- Send the source and sense calibration commands using the multimeter reading for the parameter. For example:

  :CAL:PROT:SOUR 1E-6
  :CAL:PROT:SENS 1E-6
- Set the source to the positive full-range value using the :SOUR:CURR command. For example, for the 1mA range:

  :SOUR:CURR 1E-3
- Note and record the multimeter reading.
- Send the source and sense commands using the multimeter reading as the parameter. For example:

  :CAL:PROT:SOUR 1.03E-3
  :CAL:PROT:SENS 1.03E-3
- Send the :SOUR:CURR 0.0 command to set the source current to 0A.
- Note and record the multimeter reading.
- Send the :CAL:PROT:SOUR command using the multimeter reading as the command parameter. For example:

  :CAL:PROT:SOUR 1E-6

4. Connect the 1Ω resistor and DMM to the Model 2420 INPUT/OUPUT jacks, as shown in Figure 2-3. Select the DMM DC volts function.
5. Repeat step 3 for the 3A range using the calculated current as follows: I = V/R, where V is the DMM voltage reading, and R is the characterized value of the 1Ω resistor.

Table 2-10
Current calibration initialization commands

Command	Descripton
:SOUR:FUNC CURR	Select source current mode.
:SENS:VOLT:PROT 20	Voltage limit when current source is active.
:SENS:VOLT:RANG 20	Make sure 60V range is not active.
:OUTP:STAT ON	Turn source on.

Table 2-11
Current range calibration commands

Step	Command/procedure*	Description
1	:SOUR:CURR:RANGE <Range>	Select source range.
2	:SOUR:CURR -<Source_value>	Establish negative full-range polarity.
3	Take DMM reading.	Read actual output value.
4	:CAL:PROT:SOUR <DMM_Reading>	Calibrate sense function negative full scale.
5	Check 2420 for errors.	
6	:CAL:PROT:SENS <DMM_Reading>	Calibrate source function negative full scale.
7	Check 2420 for errors.	
8	:SOUR:CURR 0.0	Set output to 0A.
9	Take DMM reading.	Read actual output value.
10	:CAL:PROT:SOUR <DMM_Reading>	Calibrate sense function negative zero.
11	Check 2420 for errors.	
12	:CAL:PROT:SENS <DMM_Reading>	Calibration source function negative zero.
13	Check 2420 for errors.	
14	:SOUR:CURR +<Source_value>	Establish positive full-range polarity.
15	Take DMM reading.	Read actual output value.
16	:CAL:PROT:SOUR <DMM_Reading>	Calibrate sense function positive full scale.
17	Check 2420 for errors.	
18	:CAL:PROT:SENS <DMM_Reading>	Calibrate source function positive full scale.
19	Check 2420 for errors.	
20	:SOUR:CURR 0.0	Set output to 0A.
21	Take DMM reading.	Read actual output value.
22	:CAL:PROT:SOUR <DMM_Reading>	Calibrate source positive zero.

*1. Perform complete procedure for each range, where <Range> and <Source_value> = 10E-6, 100E-6, 1E-3, 10E-3, 100E-3, 1, or 3.
2. <DMM_Reading> parameter is multimeter reading from previous step.
3. Use :SYST:ERR? query to check for errors.

Step 4: Program calibration dates

Use following commands to set the calibration date and calibration due date:

:CAL:PROT:DATE <year>, <month>, <day> (Calibration date)
:CAL:PROT:NDUE <year>, <month>, <day> (Next calibration due date)

Note that the year, month, and date must be separated by commas. The allowable range for the year is from 1997 to 2096, the month is from 1 to 12, and the date is from 1 to 31.

Step 5: Save calibration constants

Calibration is now complete, so you can store the calibration constants in EEROM by sending the following command:

:CAL:PROT:SAVE

NOTE *Calibration will be temporary unless you send the SAVE command. Also, calibration data will not be saved if (1) calibration is locked, (2) invalid data exists, or (3) all steps were not completed.*

Step 6: Lock out calibration

To lock out further calibration, send the following command after completing the calibration procedure:

```
:CAL:PROT:LOCK
```

Single-range calibration

Normally, the complete calibration procedure should be performed to ensure that the entire instrument is properly calibrated. In some instances, however, you may want to calibrate only certain ranges. To do so, complete the entire procedure only for the range(s) to be calibrated. Keep in mind, however, that you must complete all parameter steps for each source or sense range. Also be sure to set calibration dates and save calibration after calibrating the desired range(s).

3
Routine Maintenance

Introduction

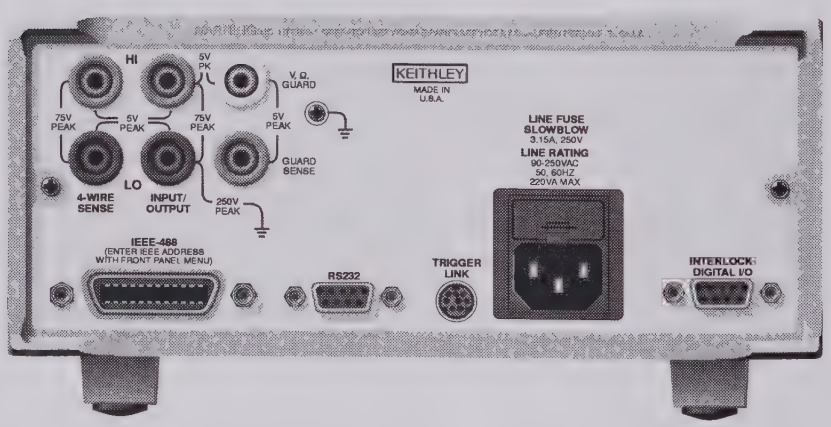
The information in this section deals with routine type maintenance that can be performed by the operator.

Line fuse replacement

WARNING **Disconnect the line cord at the rear panel, and remove all test leads connected to the instrument (front and rear) before replacing the line fuse.**

The power line fuse is accessible from the rear panel, just above the AC power receptacle (see Figure 3-1).

Figure 3-1
Rear panel



Perform the following steps to replace the line fuse:

1. Carefully grasp and squeeze together the locking tabs that secure the fuse carrier to the fuse holder.
2. Pull out the fuse carrier, and replace the fuse with the type specified in Table 3-1.

CAUTION **To prevent instrument damage, use only the fuse type specified in Table 3-1.**

3. Re-install the fuse carrier.

NOTE *If the power line fuse continues to blow, a circuit malfunction exists and must be corrected. Refer to the troubleshooting section of this manual for additional information.*

Table 3-1
Power line fuse

Line voltage	Rating	Keithley part no.
90-250V	250V, 3.15A, Slow Blow 5 × 20mm	FU-106-3.15

4
Troubleshooting

Introduction

This section of the manual will assist you in troubleshooting and repairing the Model 2420. Included are self-tests, test procedures, troubleshooting tables, and circuit descriptions. Note that disassembly instructions are located in Section 5, and component layout drawings are at the end of Section 6.

WARNING **The information in this section is intended for qualified service personnel only. Do not perform these procedures unless you are qualified to do so. Some of these procedures may expose you to hazardous voltages that could cause personal injury or death. Use caution when working with hazardous voltages.**

Repair considerations

Before making any repairs to the Model 2420, be sure to read the following considerations.

CAUTION **The PC-boards are built using surface mount techniques and require specialized equipment and skills for repair. If you are not equipped and/or qualified, it is strongly recommended that you send the unit back to the factory for repairs or limit repairs to the PC-board replacement level. Without proper equipment and training, you could damage a PC-board beyond repair.**

- Repairs will require various degrees of disassembly. However, it is recommended that the Front Panel Tests be performed prior to any disassembly. The disassembly instructions for the Model 2420 are contained in Section 5 of this manual.
- Do not make repairs to surface mount PC-boards unless equipped and qualified to do so (see previous CAUTION).
- When working inside the unit and replacing parts, be sure to adhere to the handling precautions and cleaning procedures explained in Section 5.
- Many CMOS devices are installed in the Model 2420. These static-sensitive devices require special handling as explained in Section 5.
- Whenever a circuit board is removed or a component is replaced, the Model 2420 must be recalibrated. See Section 2 for details on calibrating the unit.

Power-on self-test

During the power-on sequence, the Model 2420 will perform a checksum test on its EPROM and test its RAM. If one of these tests fails, the instrument will lock up.

Front panel tests

There are three front panel tests: one to test the functionality of the front panel keys and two to test the display. In the event of a test failure, refer to Display board checks for details on troubleshooting the display board.

KEYS test

The KEYS test lets you check the functionality of each front panel key. Perform the following steps to run the KEYS test.

1. Display the MAIN MENU by pressing the MENU key.
2. Select TEST, and press ENTER to display the SELF-TEST MENU.
3. Select DISPLAY-TESTS, and press ENTER to display the following menu:
   FRONT PANEL TESTS
   KEYS DISPLAY-PATTERNS CHAR-SET
4. Select KEYS, and press ENTER to start the test. When a key is pressed, the label name for that key will be displayed to indicate that it is functioning properly. When the key is released, the message "No keys pressed" is displayed.
5. Pressing EXIT tests the EXIT key. However, the second consecutive press of EXIT aborts the test and returns the instrument to the SELF-TEST MENU. Continue pressing EXIT to back out of the menu structure.

DISPLAY PATTERNS test

The display test lets you verify that each pixel and annunciator in the vacuum fluorescent display is working properly. Perform the following steps to run the display test:

1. Display the MAIN MENU by pressing the MENU key.
2. Select TEST, and press ENTER to display the SELF-TEST MENU.
3. Select DISPLAY-TESTS, and press ENTER to display the following menu:
   FRONT PANEL TESTS
   KEYS DISPLAY-PATTERNS CHAR-SET
4. Select DISPLAY-PATTERNS, and press ENTER to start the display test. There are five parts to the display test. Each time a front panel key (except EXIT) is pressed, the next part of the test sequence is selected. The five parts of the test sequence are as follows:
   - Checkerboard pattern (alternate pixels on) and all annunciators.
   - Checkerboard pattern and the annunciators that are on during normal operation.
   - Horizontal lines (pixels) of the first digit are sequenced.
   - Vertical lines (pixels) of the first digit are sequenced.
   - Each digit (and adjacent annunciator) is sequenced. All the pixels of the selected digit are on.
5. When finished, abort the display test by pressing EXIT. The instrument returns to the FRONT PANEL TESTS MENU. Continue pressing EXIT to back out of the menu structure.

CHAR SET test

The character set test lets you display all characters. Perform the following steps to run the character set test:

1. Display the MAIN MENU by pressing the MENU key.
2. Select TEST, and press ENTER to display the SELF-TEST MENU.
3. Select DISPLAY-TESTS, and press ENTER to display the following menu:
   FRONT PANEL TESTS
   KEYS DISPLAY-PATTERNS CHAR-SET
4. Select CHAR-SET, and press ENTER to start the character set test. Press any key except EXIT to cycle through all displayable characters.
5. When finished, abort the character set test by pressing EXIT. The instrument returns to the FRONT PANEL TESTS MENU. Continue pressing EXIT to back out of the menu structure.

Principles of operation

The following information is provided to support the troubleshooting tests and procedures covered in this section of the manual. Refer to the following drawings:

Figure 4-1 — Overall block diagram
Figure 4-2 — Analog circuitry block diagram
Figure 4-3 — Power supply block diagram
Figure 4-4 — Output stage simplified schematic
Figure 4-5 — Digital circuitry block diagram

Overall block diagram

Figure 4-1 shows an overall block diagram of the Model 2420. Circuitry may be divided into three general areas:

- Analog circuits — includes sourcing circuits such as the DACs, clamps, output stage, and feedback circuits, as well as measurement circuits such as the A/D converter.
- Digital circuits — includes the microcomputer that controls the analog section, front panel, and GPIB and RS-232 ports, as well as associated interfacing circuits.
- Power supplies — converts the AC line voltage into DC voltages that supply the power for the digital and analog circuits, and the output stage.

Analog circuits

Figure 4-2 shows the analog circuitry block.

Figure 4-1
Overall block diagram

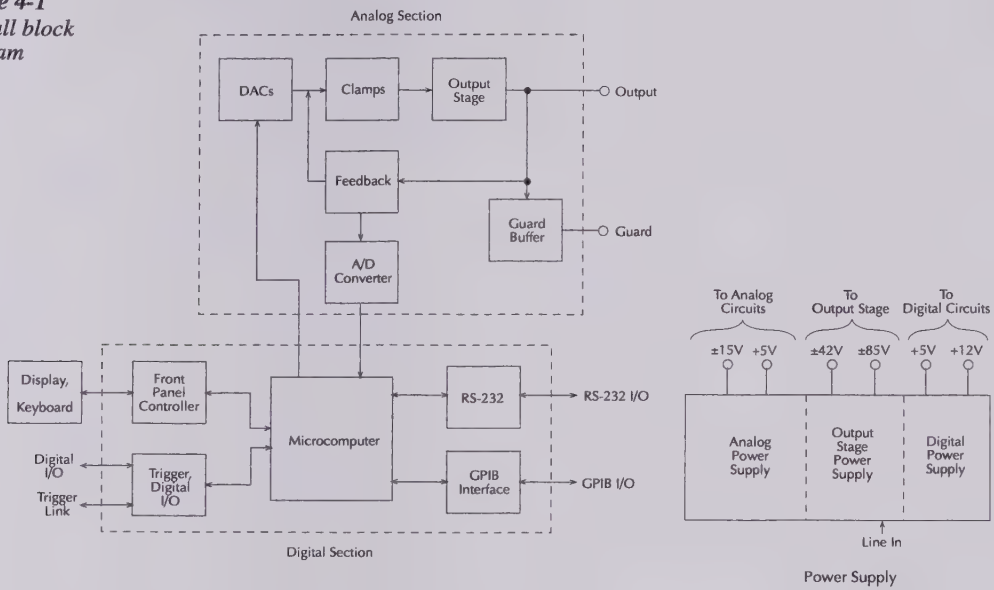
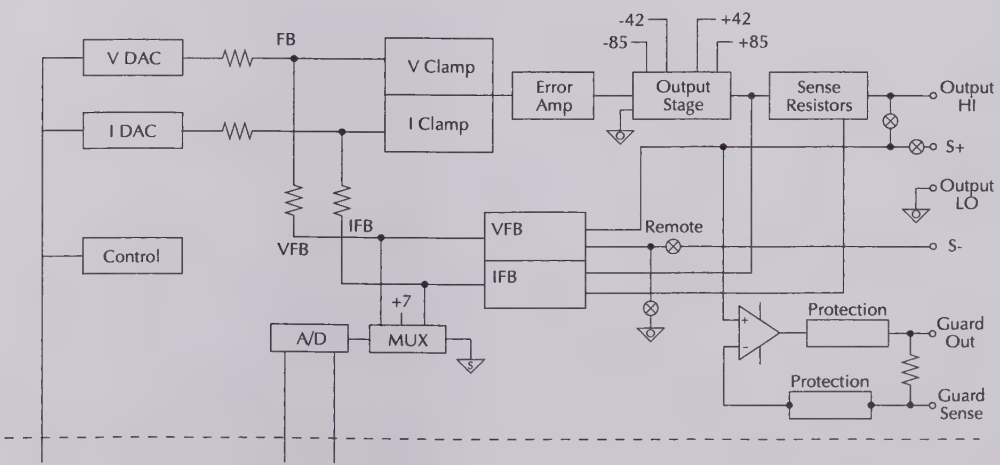


Figure 4-2
Analog circuitry block diagram



D/A converters control the programmed voltage and current, or voltage compliance and current compliance. Each DAC has two ranges, a 10V full-scale output or a 1V full-scale output. The DAC outputs are fed to the summing node, FB. Either the V DAC or the I DAC has the ability to control the main loop. If the unit is set for SV (source voltage), it will source voltage until the compliance current is reached (as determined by the I DAC setting), and the current loop will override the voltage loop. If, however, the unit is set for SI (source current), it will source current until the compliance voltage is reached (as determined by the V DAC setting), and the voltage loop will override the current loop. A priority bit in the Vclamp/I clamp circuit controls these functions.

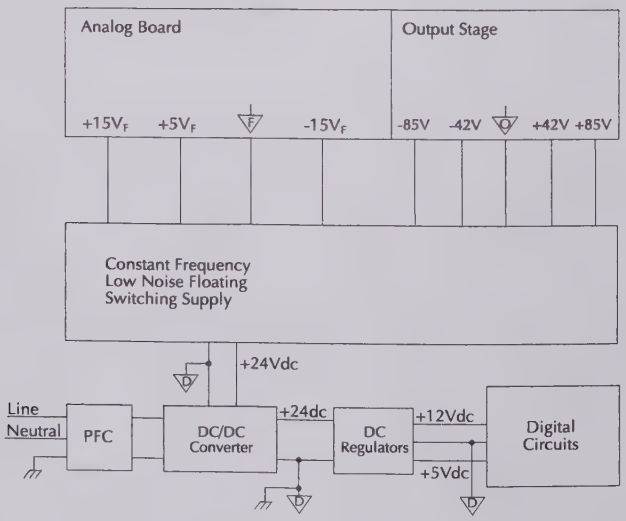
The error amplifier adds open-loop gain and slew-rate control to the system to assure accuracy and provide a controllable signal for the output stage, which provides the necessary voltage and current gain to drive the output. Sense resistors in the HI output lead provide output current sensing, and a separate sense resistor is used for each current range. The 1A and 3A ranges use 0.2V full-scale for a full-range output, while all other ranges use 2V output for full-scale current. Voltage feedback is routed either internally or externally.

There are four voltage ranges: 0.2V, 2V, 20V, and 60V. The feedback gain changes only for the 20V and 60V ranges, resulting in three unique feedback gain values. A multiplexer directs the voltage feedback, current feedback, reference, or ground signal to the A/D converter. An opto-isolated interface provides control signals for both DACs, analog circuit control, and A/D converter communication to the digital section.

Power supply

Figure 4-3 shows a block diagram of the Model 2420 power delivery system.

Figure 4-3
Power supply block diagram



The offline switching power supply provides all power for the instrument while providing universal inputs and power factor correction for the 110/120V line. The digital board runs off of 5V and 12V supplies derived from the switcher. The +12VD supply is set to program the flash ROM. (See Digital circuitry below.)

A constant-frequency switching supply runs off the +24VD supplies and generates all the floating and output supply voltages for the analog board: +5V and ±15V, ±42V and ±85V.

Output stage

Figure 4-4 shows a simplified schematic of the output stage.

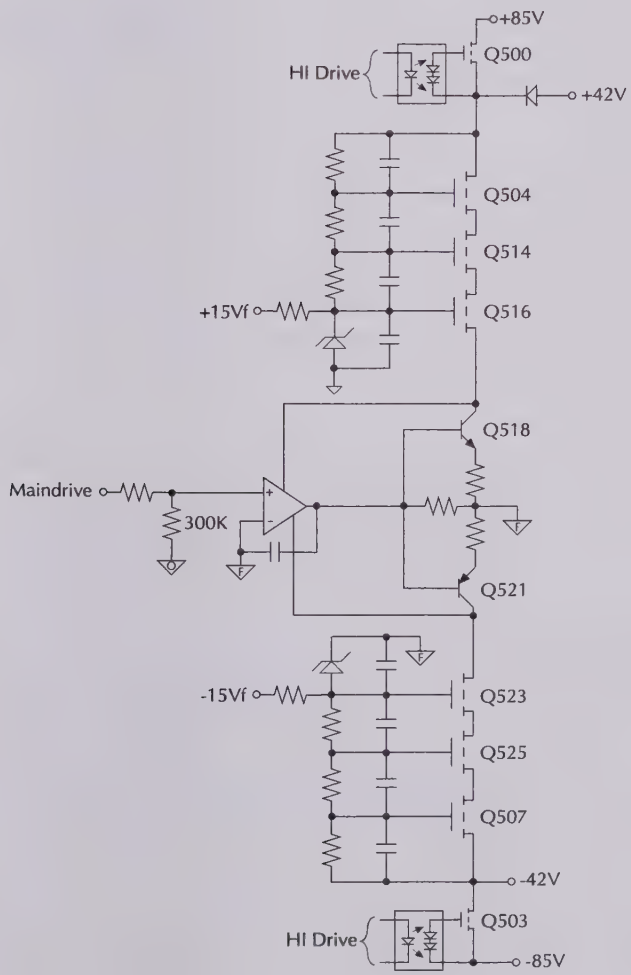


Figure 4-4
Output stage simplified schematic

The Model 2420 output stage serves two purposes: (1) it converts signals from floating common to output common, and (2) it provides both voltage and current amplification. The output stage drive transistors are biased in class B configuration to prevent the possibility of thermal runaway with high-current output values.

Output transistors Q518 and Q521 are cascoded with output MOSFETs Q516 and Q523. All other MOSFETs and transistors are slaves, and the voltages across these devices are determined by the resistor-capacitor ladder circuits shown. High-current drive capability is provided by Q500-Q511. Coarse current limits are built into the output stage.

A/D converter

The SourceMeter unit uses a multi-slope charge balance A/D converter with a single-slope run-down. The converter is controlled by gate array U610. Commands are issued by the MPU on the digital board through communications opto-isolators to U610, and U610 sends A/D reading data back through opto-isolators to the digital board for calibration and processing.

Active guard

The Model 2420 has an active guard or "six-wire ohms" circuit used to measure complex devices. This circuitry provides a low-current (50mA) equivalent of the voltage on output HI. If the unit is in the SV mode, the low-current equivalent of the source voltage will appear on the guard terminal. If the unit is in the SI mode, the voltage on output HI is equal to the source current multiplied by the external resistance value. An equivalent voltage will be generated by the guard circuit, and a guard sense terminal is provided to sense around the voltage drop in the guard leads since significant current can flow (50mA).

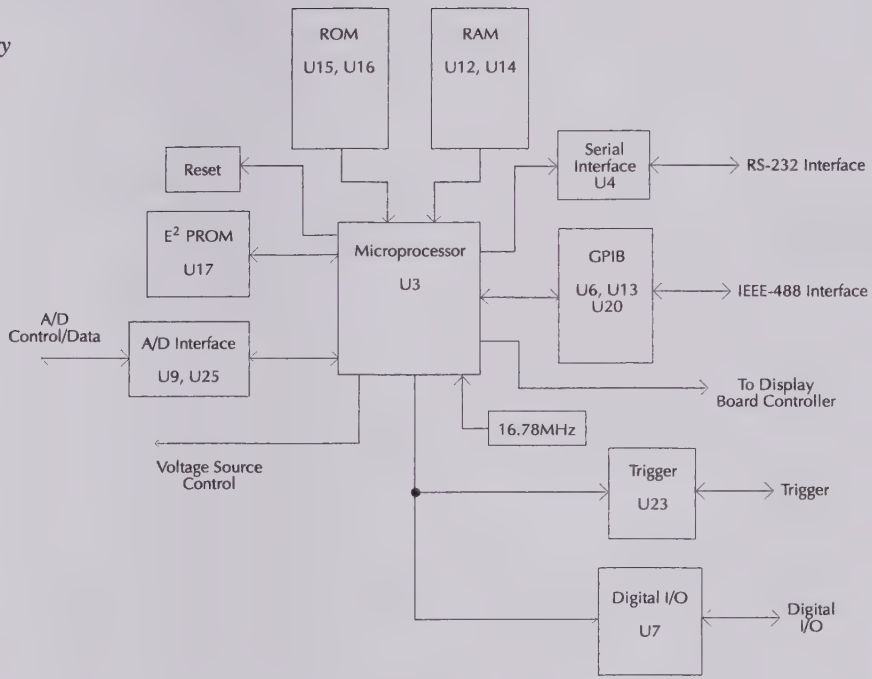
Digital circuitry

Refer to Figure 4-5 for the following discussion on digital circuitry.

The core digital circuitry uses a Motorola 68332 microcontroller running at 16.78MHz. The memory configuration includes two 256K X 8-bit flash EEPROMs and two 128K X 8-bit RAMs used in parallel to utilize the 16-bit data bus of the MPU. The RAM is battery backed-up, providing continued storage of data buffer information during power-down cycles, and flash ROM support allows internal firmware upgrades using either the serial or GPIB port for downloading new firmware. All calibration constants and the save 0 setup are stored in a separate serial EEPROM. Setups 1 through 4 are stored in battery backed-up RAM.

External communication is provided via GPIB and serial interfaces. A 9914 GPIB IEEE-488 standard interface IC is used for the GPIB, and a 68332 Queued Serial Module (QSM) provides the serial UART. For internal communications, the Time Processing Unit (TPU) is used for serial communications with the front panel display module, and both the TPU and QSM handle digital-to-analog interfacing.

Figure 4-5
Digital circuitry block diagram



Display board circuit theory

Display board components are shown in the digital circuitry block diagram in Figure 4-5.

U902 is the display microcontroller that controls the VFD (vacuum fluorescent display) and interprets key data. The microcontroller has four peripheral I/O ports that are used for the various control and read functions.

Display data is serially transmitted to the microcontroller from the digital board via the TXB line to the microcontroller PD0 terminal. In a similar manner, key data is serially sent back to the digital board through the RXB line via PD1. The 4MHz clock for the microcontroller is generated on the digital board.

DS901 is the VFD (vacuum fluorescent display) module, which can display up to 49 characters. Each character is organized as a 5 × 7 matrix of dots or pixels and includes a long underbar segment to act as a cursor.

The display uses a common multiplexing scheme with each character refreshed in sequence. U903 and U904 are the grid drivers, and U901 and U905 are the dot drivers. Note that dot driver and grid driver data is serially transmitted from the microcontroller (PD3 and PC1).

The front panel keys (S901-S931) are organized into a row-column matrix to minimize the number of microcontroller peripheral lines required to read the keyboard. A key is read by strobing the columns and reading all rows for each strobed column. Key down data is interpreted by the display microcontroller and sent back to the main microprocessor using proprietary encoding schemes.

Troubleshooting

Troubleshooting information for the various circuits is summarized below.

Display board checks

If the front panel display tests indicate that there is a problem on the display board, use Table 4-1. See Principles of operation for display circuit theory.

Table 4-1
Display board checks

Step	Item/component	Required condition	Remarks
1	Front panel test	Verify that all segments operate.	Use front panel display test.
2	J1033	+5V, ±5%	Digital +5V supply.
3	U902, pin 1	Goes low briefly on power up, and then goes high.	Microcontroller RESET.
4	U902, pin 43	4MHz square wave.	Controller 4MHz clock.
5	U902, pin32	Pulse train every 1 ms.	Control from main processor.
6	U902, pine 33	Brief pulse train when front panel key is pressed.	Key down data sent to main processor.

Power supply checks

Power supply problems can be checked out using Table 4-2. See Principles of operation for circuit theory on the power supply.

Table 4-2
Power supply checks

Step	Item.component	Required condition	Remarks
1	Line fuse	Check continuity.	Remove to check.
2	Line power	Plugged into live receptacle, power on.	Check for correct power-up sequence.
3	TP502	+80V, ±10%	Referenced to TP501.
4	TP503	-80V, ±10%	Referenced to TP501.
5	TP504	+38V, ±10%	Referenced to TP501.
6	TP505	-38V, ±10%	Referenced to TP501.
7	TP507	+15V, ±5%	+15VF, referenced to TP500.
8	TP508	-15V, ±5%	-15VF, referenced to TP500.
9	TP510	+5V, ±5%	+5VF, referenced to TP500.

Digital circuitry checks

Digital circuit problems can be checked out using Table 4-3. See Principles of operation for a digital circuit description.

Table 4-3
Digital circuitry checks

Step	Item/component	Required condition	Remarks
1	Power-on test	RAM OK, ROM OK.	Verify that RAM and ROM are functional.
2	U3 pin 19	Digital common. common.	All signals referenced to digital common.
3	U3 pin 7	+5V	Digital logic supply.
4	U3 pin 68	Low on power-up, then goes high.	MPU RESET line.
5	U3, lines A0-A19	Check for stuck bits.	MPU address bus.
6	U3, lines D0-D15	Check for stuck bits.	MPU data bus.
7	U3 pin 66	16.78MHz.	MPU clock.
8	U4 pin 7	Pulse train during RS-232 I/O.	RS-232 RX line.
9	U4 pin 8	Pulse train during RS-232 I/O.	RS-232 TX line.
10	U13 pins 34-42	Pulse train during IEEE-488 I/O.	IEEE-488 data bus.
11	U13 pins 26-31	Pulses during IEEE-488 I/O.	IEEE-488 command lines.
12	U13 pin 24	Low with remote enabled.	IEEE-488 REN line.
13	U13 pin 25	Low during interface clear.	IEEE-488 IFC line.
14	U3 pin 43	Pulse train.	D_ADDATA
15	U3 pin 44	Pulse train.	D_DATA
16	U3 pin 45	Pulse train.	D_CLK
17	U3 pin 47	Pulse train	D_STB

Analog circuitry checks

Table 4-4 summarizes analog circuitry checks.

Table 4-4
Analog circuitry checks

Step	Item/component	Required condition	Remarks
1	TP200*	>60V voltage protection	-13V ±1V
2	TP201*	SOURCE +10V	-5V ±0.5V
3	TP202*	SOURCE +10V (SVMI)	-10V ±1V
4	TP203*	SOURCE +10V	-10.5V ±1V
5	TP213*	SOURCE +10V	0V ±0.1V
6	TP218**	OUTPUT COM	7V ±0.7V
7	TP219**	OUTPUT COM	7V ±0.7V
8	TP214**	SVMI, OUTPUT ON, 20V	20V ±0.5V
9	TP232*	Bench defaults	6.4V ±0.6V

*Measured with respect to FCOM (TP500).
**Measured with respect to OCOM (TP501).

Battery replacement

WARNING **Disconnect the instrument from the power line and all other equipment before changing the battery.**

The volatile memories of the Model 2420 are protected by a replaceable battery when power is off. Typical battery life is approximately 10 years. The battery should be suspected if the instrument no longer retains buffer data or user-defined operating parameters such as instrument setups, source memory, and math expressions. If the battery is absent or totally exhausted, the display will show the "Reading buffer data lost" message shortly after the Model 2420 is switched on.

The battery is a 3V wafer-type lithium cell, Panasonic type BR-2330 or equivalent (Keithley part number BA-46), which is located on the digital board. Replacement of the battery requires removal of the case cover and analog board assembly. (See Section 5.)

Battery replacement precautions

WARNING **The precautions below must be followed to avoid personal injury.**

1. Wear safety glasses or goggles when working with lithium batteries.
2. Do not short the battery terminals together.
3. Keep lithium batteries away from all liquids.
4. Do not attempt to recharge lithium batteries.
5. Observe proper polarity when installing the battery.
6. Do not incinerate or otherwise expose the battery to excessive heat (>60°C).
7. Bulk quantities of lithium batteries should be disposed of as hazardous waste.

Battery replacement procedure

1. Remove the case cover and analog board assembly as covered in Section 5.
2. Locate the battery on the digital board.
3. Carefully unsolder and remove the old battery.
4. Install and solder the new battery in place.
5. Re-assemble the instrument, and turn it on. The "Reading buffer data lost" error message will be displayed.
6. Send the :SYST:MEM:INIT command via remote to perform the following:
   - Clear the reading buffer.
   - Initialize instrument setups 1 through 4 to present instrument settings.
   - Initialize all 100 source memory locations to present instrument settings.
   - Delete user math expressions.

No comm link error

A "No Comm Link" error indicates that the front panel processor has stopped communicating with the main processor, which is located on the digital board. This error indicates that one of the main processor ROMs may require re-seating in its socket. ROMs may be reseated as follows:

1. Turn off the power, and disconnect the line cord and all other test leads and cables from the instrument.
2. Remove the case cover as outlined in Section 5.
3. Remove the analog board assembly as outlined in Section 5.
4. Locate the two firmware ROMS, U15 and U16, located on the digital board. These are the only ICs installed in sockets. (Refer to the component layout drawing at the end of Section 6 for exact locations.)
5. Carefully push down on each ROM IC to make sure it is properly seated in its socket.

CAUTION **Be careful not to push down excessively, or you might crack the digital board.**

6. Connect the line cord, and turn on the power. If the problem persists, additional troubleshooting will be required.

5
Disassembly

Introduction

This section explains how to handle, clean, and disassemble the Model 2420. Disassembly drawings are located at the end of this section.

Handling and cleaning

To avoid contaminating PC board traces with body oil or other foreign matter, avoid touching the PC board traces while you are repairing the instrument. Motherboard areas covered by the shield have high-impedance devices or sensitive circuitry where contamination could cause degraded performance.

Handling PC boards

Observe the following precautions when handling PC boards:

- Wear cotton gloves.
- Only handle PC boards by the edges and shields.
- Do not touch any board traces or components not associated with repair.
- Do not touch areas adjacent to electrical contacts.
- Use dry nitrogen gas to clean dust off PC boards.

Solder repairs

Observe the following precautions when you must solder a circuit board:

- Use an OA-based (organic activated) flux, and take care not to spread the flux to other areas of the circuit board.
- Remove the flux from the work area when you have finished the repair by using pure water with clean, foam-tipped swabs or a clean, soft brush.
- Once you have removed the flux, swab only the repair area with methanol, then blow-dry the board with dry nitrogen gas.
- After cleaning, allow the board to dry in a 50°C, low-humidity environment for several hours.

Static sensitive devices

CMOS devices operate at very high impedance levels. Therefore, any static that builds up on you or your clothing may be sufficient to destroy these devices if they are not handled properly. Use the following precautions to avoid damaging them:

CAUTION **Many CMOS devices are installed in the Model 2420. Handle all semiconductor devices as being static sensitive.**

- Transport and handle ICs only in containers specially designed to prevent static build-up. Typically, you will receive these parts in anti-static containers made of plastic or foam. Keep these devices in their original containers until ready for installation.
- Remove the devices from their protective containers only at a properly grounded work station. Also, ground yourself with a suitable wrist strap.
- Handle the devices only by the body; do not touch the pins.
- Ground any printed circuit board into which a semiconductor device is to be inserted to the bench or table.
- Use only anti-static type desoldering tools.
- Use only grounded-tip solder irons.
- Once the device is installed in the PC board, it is normally adequately protected, and you can handle the boards normally.

Assembly drawings

Use the assembly drawings located at the end of this section to assist you as you disassemble and re-assemble the Model 2420. Also, refer to these drawings for information about the Keithley part numbers of most mechanical parts in the unit. Assembly drawings include:

- Front panel assembly — 2420-040
- Analog board/heat sink/shield assembly — 2420-050
- Chassis assembly — 2420-051
- Chassis/analog board assembly — 2420-052
- Final chassis assembly — 2420-053

Case cover removal

Follow the steps below to remove the case cover to gain access to internal parts.

WARNING **Before removing the case cover, disconnect the line cord and any test leads from the instrument.**

1. **Remove handle** — The handle serves as an adjustable tilt-bail. Adjust its position by gently pulling it away from the sides of the instrument case and swinging it up or down. To remove the handle, swing the handle below the bottom surface of the case and back until the orientation arrows on the handles line up with the orientation arrows on the mounting ears. With the arrows lined up, pull the ends of the handle away from the case.

2. **Remove mounting ears** — Remove the screw that secures each mounting ear. Pull down and out on each mounting ear.

NOTE *When re-installing the mounting ears, make sure to mount the right ear to the right side of the chassis, and the left ear to the left side of the chassis. Each ear is marked "RIGHT" or "LEFT" on its inside surface.*

3. **Remove rear bezel** — To remove the rear bezel, loosen the two screws that secure the rear bezel to the chassis, then pull the bezel away from the case.
4. **Remove grounding screws** — Remove the two grounding screws that secure the case to the chassis. They are located on the bottom of the case at the back.
5. **Remove chassis** — To remove the case, grasp the front bezel of the instrument, and carefully slide the chassis forward. Slide the chassis out of the metal case.

NOTE *To gain access to the components under the analog board shield, remove the shield, which is secured to the analog board by a single screw.*

Analog board removal

Perform the following steps to remove the analog board . This procedure assumes that the case cover is already removed.

1. Disconnect the front and rear input terminals.
   You must disconnect these input terminal connections for both the front and rear inputs:
   - INPUT/OUTPUT HI and LO
   - 4-WIRE SENSE HI and LO
   - V, Ω, GUARD and GUARD SENSE (rear panel only)

Remove all the connections by pulling the wires off the pin connectors, then remove the ferrite noise filters from the chassis. During re-assembly, use the following table to identify input terminals:

Input terminals	Front wire color	Rear wire color
INPUT/OUTPUT HI	Red	White/Red
INPUT/OUTPUT LO	Black	White/Black
4-WIRE SENSE HI	Yellow	White/Yellow
4-WIRE SENSE LO	Gray	White/Gray
V, Ω, GUARD	-	White
GUARD SENSE	-	Blue/White

2. Unplug cables.
   - Carefully unplug the ribbon cables at J1027, J1028, and J1029.
   - Unplug the ON/OFF cable at J1034.

3. Remove screws.
   - Remove the two fastening screws that secure the analog board assembly to the chassis. These screws are located on the side of the board opposite from the heat sink.
   - Remove the two screws that secure the heat sink to the chassis.
4. Remove analog board assembly.
   After all screws have been removed, carefully lift the analog board assembly free of the main chassis.
5. Disassemble analog board assembly.
   - Remove the screws that secure the analog board and heat sink to the analog board subchassis.
   - Carefully remove the heat sink by sliding the clips off the power transistors.

CAUTION **Be careful not to damage the heat sink insulation layer.**

   - Remove the analog board from the subchassis.
   - Remove the four screws that secure the bottom cover, then remove the cover from the bottom of the PC board.

NOTE *When re-installing the heat sink, make sure that all clips are properly installed and centered on each pair of output transistors.*

Digital board removal

Perform the following steps to remove the digital board. This procedure assumes that the analog board assembly is already removed.

NOTE *In order to remove the digital board, the display board must first be removed.*

1. Remove the IEEE-488, Digital I/O, and RS-232 fasteners.
   The IEEE-488, Digital I/O, and RS-232 connectors each have two nuts that secure the connectors to the rear panel. Remove these nuts.
2. Remove the POWER switch rod.
   At the switch, place the edge of a flat-blade screw driver in the notch on the pushrod. Gently twist the screw driver while pulling the rod from the shaft.
3. Unplug cables:
   - Unplug the display board ribbon cable.
   - Unplug the cables going to the power supply.
   - Unplug the rear panel power module cable.
   - The fan may need to be removed.
4. Remove digital board.
   Slide the digital board forward until it is free of the guide pins, then remove the board.

   During re-assembly, replace the board, and start the IEEE-488, Digital I/O, and RS-232 connector nuts and the mounting screw. Tighten all the fasteners once they are all in place and the board is correctly aligned.

Front panel disassembly

Use the following procedures to remove the display board and/or the pushbutton switch pad.

1. Unplug the display board ribbon cables.
2. Remove the front panel assembly.
   This assembly has four retaining clips that snap onto the chassis over four pem nut studs. Two retaining clips are located on each side of the front panel. Pull the retaining clips outward and, at the same time, pull the front panel assembly forward until it separates from the chassis.
3. Using a thin-bladed screw driver, pry the plastic PC board stop (located at the bottom of the display board) until the bar separates from the casing. Pull the display board from the front panel.
4. Remove the switch pad by pulling it from the front panel.

Removing power components

The following procedures to remove the power supply and/or power module require that the case cover and motherboard be removed, as previously explained.

Power module removal

Perform the following steps to remove the rear panel power module:

1. Remove the analog board.
2. Unplug the cable connecting the power module to the digital board.
3. Disconnect the power module's ground wire. This green and yellow wire connects to a threaded stud on the chassis with a kep nut.
4. Squeeze the latches on either side of the power module while pushing the module from the access hole.

WARNING **To avoid electrical shock, which could result in injury or death, the ground wire of the power module must be connected to chassis ground. When installing the power module, be sure to re-connect the green and yellow ground wire to the threaded stud on the chassis.**

Instrument re-assembly

Re-assemble the instrument by reversing the previous disassembly procedures. Make sure that all parts are properly seated and secured, and that all connections are properly made. To ensure proper operation, replace the analog signal wire ferrite noise filters, and securely fasten the shield.

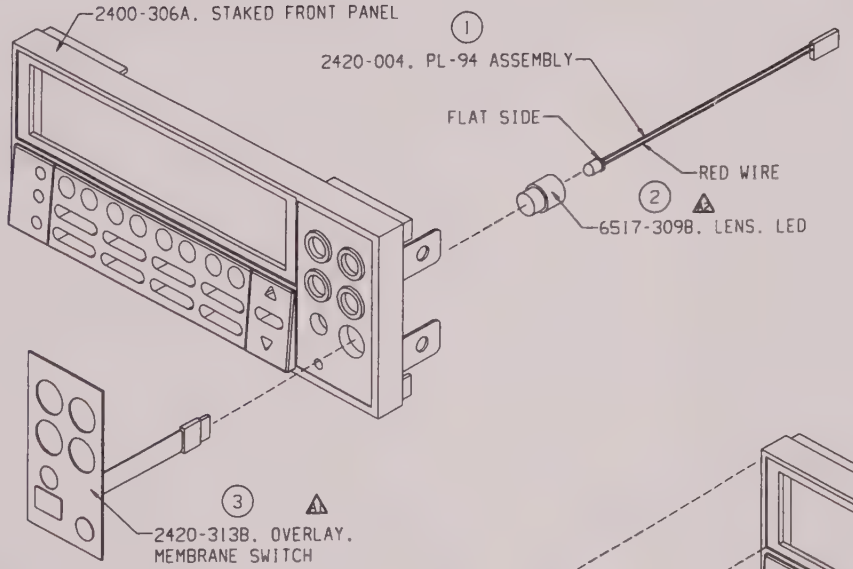
WARNING **To ensure continued protection against electrical shock, verify that power line ground (green and yellow wire attached to the power module) is connected to the chassis.**

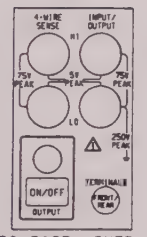
Also make sure the two bottom case screws are properly installed to secure and ground the case cover to the chassis.

NO. 2420-040

LTR	ECA NO.	REVISION	ENG	DATE
A	19687	Released	ST	3/3/97
A1	19797	2420-313B WAS 2420-313A	ST	5/22/97
A2	21728	6517-309B WAS 6517-309A	ST	8/3/98
A3	21587	2420-311B Was 2420-311A	ST	12/2/98

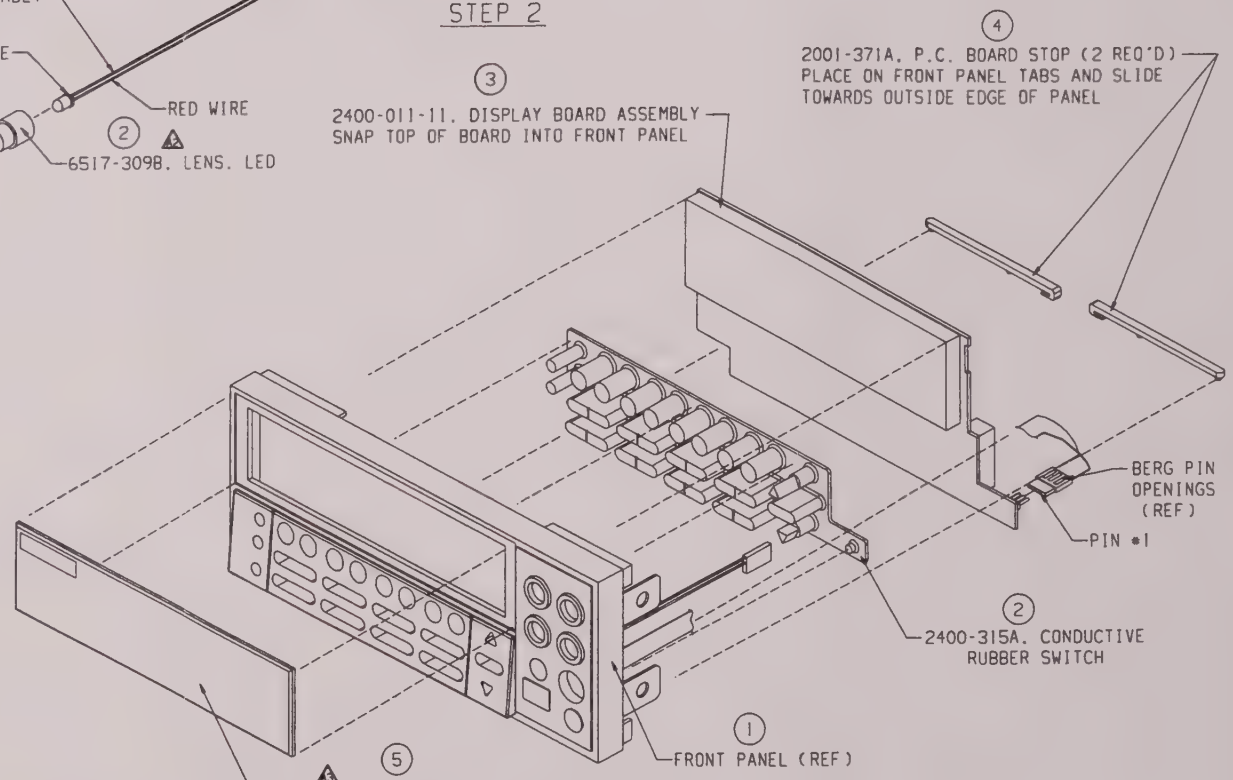
STEP 1





2420-313B. OVERLAY. MEMBRANE SWITCH (REF VIEW) ⚠1

STEP 2


4
2001-371A. P.C. BOARD STOP (2 REQ'D) PLACE ON FRONT PANEL TABS AND SLIDE TOWARDS OUTSIDE EDGE OF PANEL
3
2400-011-11. DISPLAY BOARD ASSEMBLY SNAP TOP OF BOARD INTO FRONT PANEL
BERG PIN OPENINGS (REF)
PIN #1
2
2400-315A. CONDUCTIVE RUBBER SWITCH
1
FRONT PANEL (REF)
⚠3
5
2420-311B. DISPLAY LENS DO NOT REMOVE GREEN MASK. FROM LENS

PART NUMBER	QTY	DESCRIPTION
2400-306A	1	FRONT PANEL. STAKED
2400-011-11	1	DISPLAY BOARD ASSEMBLY
2420-313B	1	OVERLAY. MEMBRANE SWITCH ⚠1
2420-311B	1	DISPLAY LENS ⚠3
2400-315A	1	CONDUCTIVE RUBBER SWITCH
2001-371A	2	P.C. BOARD STOP
6517-309B	1	LENS. LED ⚠2
2420-004	1	CRIMP ASSEMBLY

MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY
2420	2420-052	Chassis/Analog Brd Ass'y	1

USED ON

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DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

XX • ±.015 ANG • ±1°

XXX • ±.005 FRAC • ±1/64

SURFACE MAX 63

DATE 11/19/96 SCALE 2/3

DRN mat ENG APPR JAK

MATERIAL

FINISH

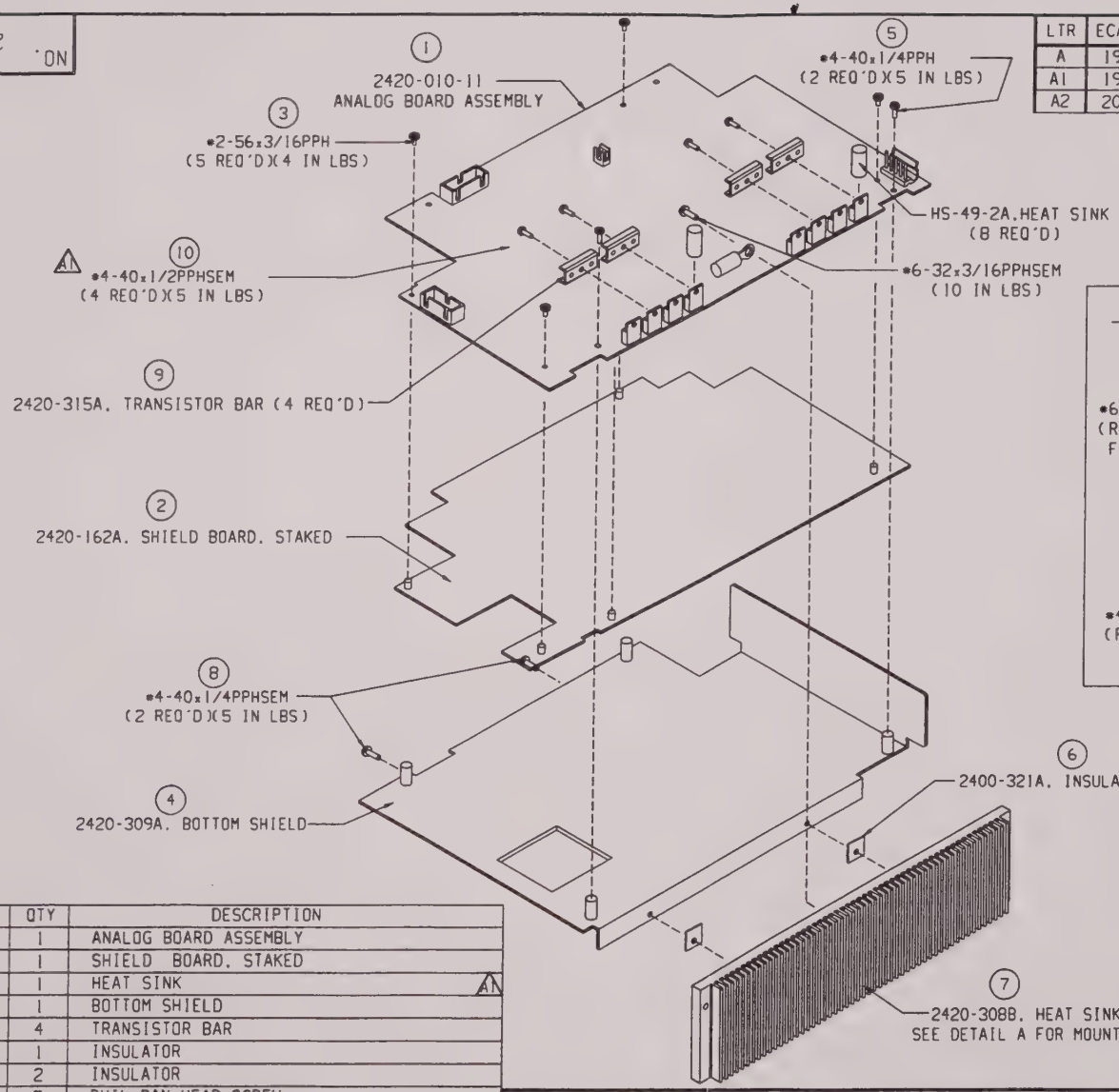
TITLE FRONT PANEL ASSEMBLY OP6

B NO. 2420-040

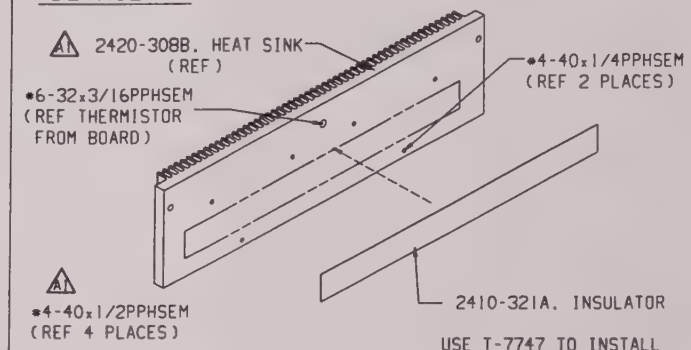
ORIGINAL IF RED

NO. 2420-050

LTR	ECA NO.	REVISION	ENG	DATE
A	19687	Released	ST	3/3/97
A1	19905	2420-308B WAS -308A; ⚬4-40X1/2PPHSEM WAS ⚬4-40X7/16PPHSEM	SZ	5/15/97
A2	20970	Detail A. Relocate Insulator	ST	1/20/98



DETAIL A A2



USE T-7747 TO INSTALL INSULATOR TO HEAT SINK

PART NUMBER	QTY	DESCRIPTION
2420-010-11	1	ANALOG BOARD ASSEMBLY
2420-162A	1	SHIELD BOARD. STAKED
2420-308B	1	HEAT SINK A1
2420-309A	1	BOTTOM SHIELD
2420-315A	4	TRANSISTOR BAR
2410-321A	1	INSULATOR
2400-321A	2	INSULATOR
⚬2-56x3/16PPH	5	PHIL PAN HEAD SCREW
⚬4-40x1/4PPHSEM	2	PHIL PAN HEAD SEM SCREW
⚬4-40x1/2PPHSEM	4	PHIL PAN HEAD SEM SCREW A1
⚬4-40x1/4PPH	2	PHIL PAN HEAD SCREW
HS-49-2A	8	HEAT SINK
⚬6-32x3/16PPHSEM	1	PHIL PAN HEAD SEM SCREW

MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY
2420	2420-052	Chassis/Analog Assembly	1

USED ON

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XX ± .015 ANG ± 1°
XXX ± .005 FRAC ± 1/64
SURFACE MAX 63

DATE 11/19/96 SCALE 2/1
DRN mat ENG APPR JAK

KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139

TITLE ANALOG BOARD/HEAT SINK/ SHIELD ASSEMBLY

MATERIAL
FINISH

B

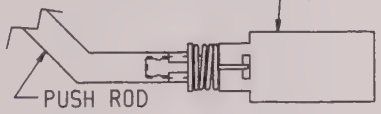
NO. 2420-050

ORIGINAL IF RED

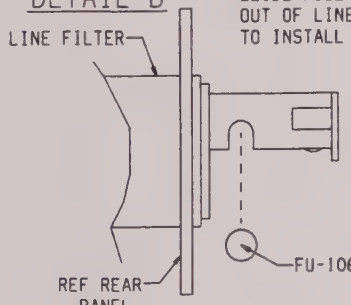
NO. 2420-051

LTR	ECA NO.	REVISION	ENG	DATE
C	19481	*4-40x1-1/4PFH Was 9/16	ST	4/7/97
C1	20420	Update View Of Fan		

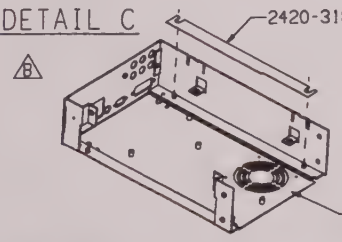
DETAIL A PROPERLY INSTALLED PUSH ROD

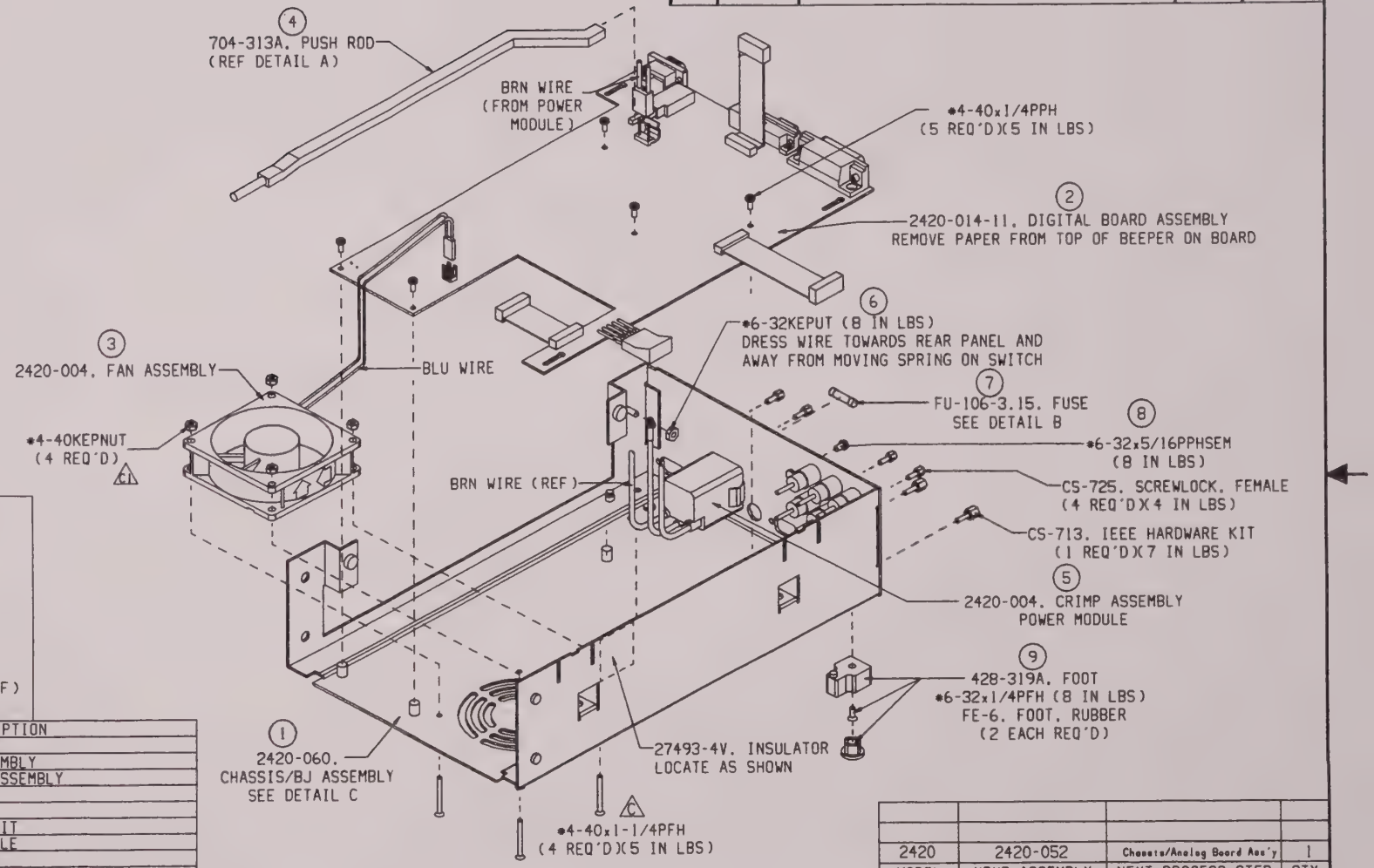


DETAIL B SLIDE FUSE DRAWER OUT OF LINE FILTER TO INSTALL FUSE



DETAIL C





PART NUMBER	QTY	DESCRIPTION
2420-004	1	CRIMP ASSEMBLY
2420-060	1	CHASSIS/BJ ASSEMBLY
2420-014-11	1	DIGITAL BOARD ASSEMBLY
428-319A	2	FOOT
704-313A	1	PUSH ROD
CS-713	1	IEEE HARDWARE KIT
CS-725	4	SCREWLOCK, FEMALE
FE-6	2	FOOT,RUBBER
FU-106-3.15	1	FUSE -- 3.15 AMP
*4-40x1/4PPH	5	PHIL PAN HEAD SCREW
*6-32KEPNUT	1	KEPNUT
*6-32x1/4PFH	2	PHIL FLAT HEAD SCREW
*6-32x5/16PPHSEM	1	PHIL PAN HEAD SEMS SCREW
*4-40x1-1/4PFH	4	PHIL FLAT HEAD SCREW
*4-40KEPNUT	4	KEPNUT
27493-4V	1	INSULATOR
2420-318A	1	INSULATOR

2420	2420-052	Chassis/Analog Board Ass'y	1
MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY
USED ON			

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DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

XX ± .015 ANG ± 1°

XXX ± .005 FRAC ± 1/64

SURFACE MAX 63

DATE 12/20/96 SCALE ℞

DRN mat ENG APPR

MATERIAL

FINISH

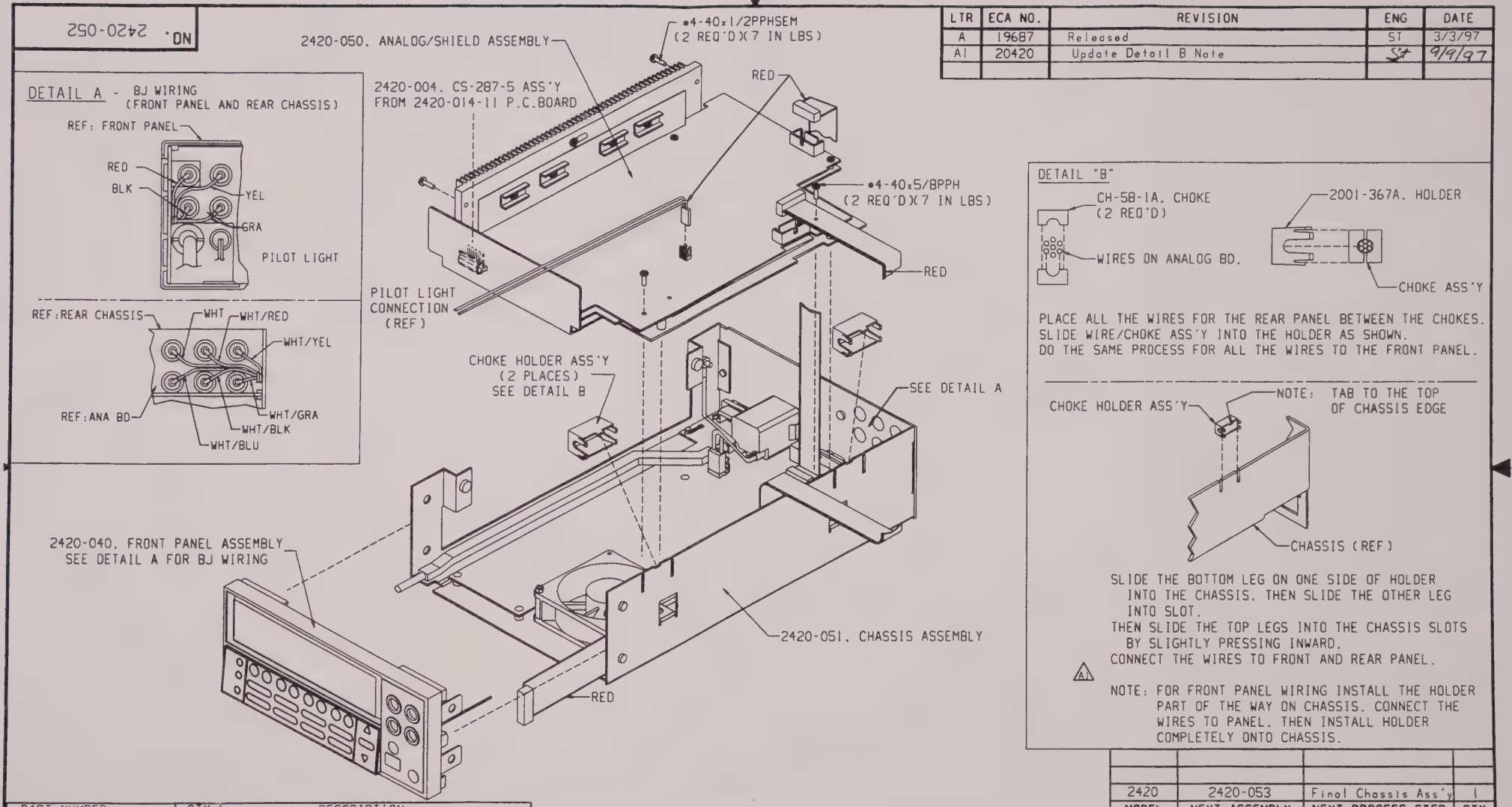
TITLE CHASSIS ASSEMBLY

B NO. 2420-051

ORIGINAL IF RED Duplicate

NO. 2420-052

LTR	ECA NO.	REVISION	ENG	DATE
A	19687	Released	ST	3/3/97
A1	20420	Update Detail B Note	ST	9/9/97


2420-050. ANALOG/SHIELD ASSEMBLY
•4-40x1/2PPHSEM (2 REQ'D)(7 IN LBS)
2420-004. CS-287-5 ASS'Y FROM 2420-014-11 P.C.BOARD
RED
•4-40x5/8PPH (2 REQ'D)(7 IN LBS)
RED
PILOT LIGHT CONNECTION (REF)
CHOKE HOLDER ASS'Y (2 PLACES) SEE DETAIL B
SEE DETAIL A
2420-040. FRONT PANEL ASSEMBLY SEE DETAIL A FOR BJ WIRING
2420-051. CHASSIS ASSEMBLY
RED
DETAIL A - BJ WIRING (FRONT PANEL AND REAR CHASSIS)
REF: FRONT PANEL
RED
BLK
YEL
GRA
PILOT LIGHT
REF:REAR CHASSIS
WHT
WHT/RED
WHT/YEL
REF:ANA BD
WHT/GRA
WHT/BLK
WHT/BLU
DETAIL "B"
CH-58-1A. CHOKE (2 REQ'D)
WIRES ON ANALOG BD.
2001-367A. HOLDER
CHOKE ASS'Y
PLACE ALL THE WIRES FOR THE REAR PANEL BETWEEN THE CHOKES.
SLIDE WIRE/CHOKE ASS'Y INTO THE HOLDER AS SHOWN.
DO THE SAME PROCESS FOR ALL THE WIRES TO THE FRONT PANEL.
CHOKE HOLDER ASS'Y
NOTE: TAB TO THE TOP OF CHASSIS EDGE
CHASSIS (REF)
SLIDE THE BOTTOM LEG ON ONE SIDE OF HOLDER INTO THE CHASSIS. THEN SLIDE THE OTHER LEG INTO SLOT.
THEN SLIDE THE TOP LEGS INTO THE CHASSIS SLOTS BY SLIGHTLY PRESSING INWARD.
CONNECT THE WIRES TO FRONT AND REAR PANEL.
⚠1
NOTE: FOR FRONT PANEL WIRING INSTALL THE HOLDER PART OF THE WAY ON CHASSIS. CONNECT THE WIRES TO PANEL. THEN INSTALL HOLDER COMPLETELY ONTO CHASSIS.

PART NUMBER	QTY	DESCRIPTION
2420-040	1	FRONT PANEL ASSEMBLY
2420-050	1	ANALOG BOARD/SHIELD ASSEMBLY
2420-051	1	CHASSIS ASSEMBLY
•4-40x5/8PPH	2	PHIL PAN HEAD SCREW
CH-58-1A	4	CHOKE
2001-367A	2	HOLDER
•4-40x1/2PPHSEM	2	PHIL PAN HEAD SEM SCREW

MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY
2420	2420-053	Final Chassis Ass'y	1

USED ON

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DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED
XX • ±.015 ANG • ±1°
XXX • ±.005 FRAC • ±1/64
SURFACE MAX 63

DATE 11/20/96 SCALE 2/1
DRN mat ENG APPR Jok
MATERIAL
FINISH

KEITHLEY Keithley Instruments Inc. Cleveland, Ohio 44139

TITLE
CHASSIS/ANALOG BOARD ASSEMBLY

B

NO. 2420-052

NO. 2420-053

TEST PROCEDURE:

Press and hold THE SWEEP and SOURCE UP ARROW key on the 2420 Display Board while powering up the instrument. this will allow access to the Secret Menu which contains the BURN-IN mode.

After power sequence is complete, verify that the display shows:

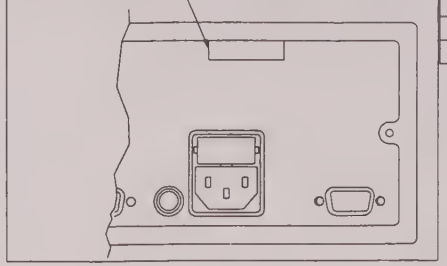
_ _ _ . _ _ _ uA OFF
Vsrc:-00.0000 V Cmpl:100.000 uA

Depress Key	Display
MENU	MAIN MENU "SAVESETUP" flashing
>arrow.4 times	"GENERAL" flashing
ENTER	GENERAL MENU "DIGOUT" flashing
>arrow.6 times	"SECRET" flashing
ENTER	SECRET MENU "INIT_BBRAM" flashing
>arrow.1 time	"DISP-BURN-IN" flashing
ENTER	ALL SEGMENTS ON

Power cycle unit and display will end up with all segments ON>. The unit is in the BURN-IN mode.

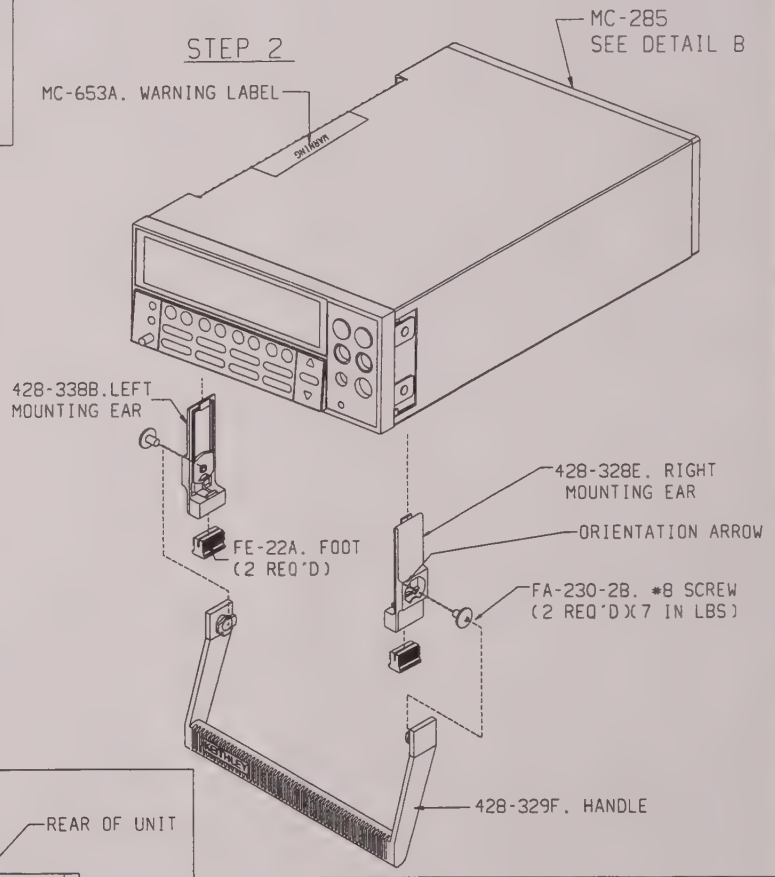
Age unit per MS-1860

DETAIL B

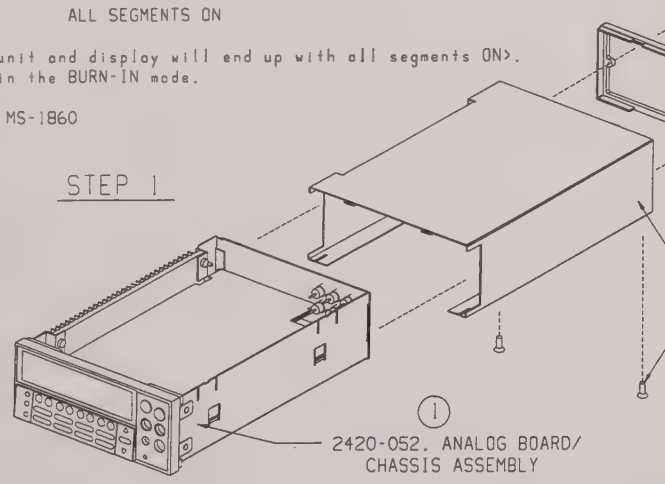


LTR	ECA NO.	REVISION	ENG	DATE
A	19697	Released	JF	3/31/97

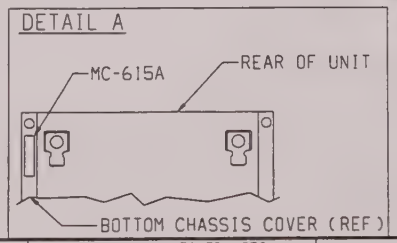
STEP 2



STEP 1



DETAIL A



PART NUMBER	QTY	DESCRIPTION
2420-052	1	ANALOG BOARD/CHASSIS ASSEMBLY
2420-317A	1	COVER
428-328E	1	MOUNTING EAR RIGHT
428-338B	1	MOUNTING EAR LEFT
FA-230-2B	2	FASTENER
FE-22A	2	FOOT
MC-615A	1	WARNING LABEL
#4-40x1/4"PFHUC	2	PHIL FLAT HD UNDERCUT SCREW
MC-285	1	SERIAL NUMBER
428-303D	1	REAR BEZEL
FA-232-1C	2	CAPTIVE PANEL SCREW
428-329F	1	HANDLE
MC-653A	1	WARNING LABEL

2420	2420-080	FINAL INSPECTION	
2420	TECH	TECH	1
MODEL	NEXT ASSEMBLY	NEXT PROCESS STEP	QTY

USED ON

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DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED

XX = ±.015 ANG = ±1°

XXX = ±.005 FRAC = ±1/64

SURFACE MAX 63

DATE 11/20/96 SCALE X

DRN Mat ENG APPR JAK

MATERIAL X

FINISH X

TITLE: FINAL CHASSIS ASSEMBLY - OP6

B NO. 2420-053

6
Replaceable Parts

Introduction

This section contains replacement parts information and component layout drawings for the Model 2420.

Parts lists

The electrical parts lists for the Model 2420 are shown tables at the end of this section. For part numbers to the various mechanical parts and assemblies, use the Miscellaneous parts list and the assembly drawings provided at the end of Section 5.

Ordering information

To place an order, or to obtain information concerning replacement parts, contact your Keithley representative or the factory (see inside front cover for addresses). When ordering parts, be sure to include the following information:

- Instrument model number (Model 2420)
- Instrument serial number
- Part description
- Component designation (if applicable)
- Keithley part number

Factory service

If the instrument is to be returned to Keithley Instruments for repair, perform the following:

- Call the Repair Department at 1-800-552-1115 for a Return Material Authorization (RMA) number.
- Complete the service form at the back of this manual, and include it with the instrument.
- Carefully pack the instrument in the original packing carton.
- Write ATTENTION REPAIR DEPARTMENT and the RMA number on the shipping label.

Component layouts

The component layouts for the various circuit boards are provided on the following pages. Drawings include:

- Analog board — 2420-100
- Display board — 2400-110
- Digital board — 2420-140

Table 6-1
Analog board parts list

Circuit designation	Description	Keithley part no.
C200-203,205-210,225,226,231, 232,237,238	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C204,411,608,609	CAP, .01UF, 10%, 50V CERAMIC	C-491-.01
C211-214	CAP, 1000PF,10%, 50V, MONO CERAMIC	C-452-1000P
C215-222,611	CAP,100PF, 5%, 100V, CERAMIC	C-465-100P
C223,224,227-230,233-236, 239,240, 320	CAP, 33PF, 5%, 100V, CERAMIC	C-465-33P
C241	CAP,1000PF,1%,50V,CERAMIC	C-347-1000P
C242,243,248,249,		
254,255,258-261,269-271	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C246,336	CAP,3300PF,10%,100V,CERAMIC	C-430-3300P
C247	CAP, .01, 5%, 50V, NPO	C-514-.01
C250,251,272,290,291,297-300,524,525	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C256,257	CAP, 22PF, 10%, 100V, CERAMIC	C-451-22P
C267,268,327	CAP, 1000P, 10%, 100V, CERAMIC	C-451-1000P
C273-282,284-289,305-310,321,322	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C283	CAP, 100P, 10%, 100V CERAMIC	C-451-100P
C301,302	CAP, 1000PF,10%, 50V, MONO CERAMIC	C-452-1000P
C311	CAP, 100UF, 20%, 10V, ALUM ELEC	C-483-100
C312-319	CAP,10PF,5%,100V,CERAMIC	C-372-10P
C323-326,603,604,615	CAP, 47P, 5%, 100V, CERAMIC	C-465-47P
C328	CAP, 33PF, 10%, 100V, CERAMIC	C-451-33P
C329	CAP, 220PF, 10%, 100V, CERAMIC	C-451-220P
C331-334	CAP,100PF, 5%, 100V, CERAMIC	C-465-100P
C400,401,296,330	CAP,270PF,2.5%,630V,POLYPROPYLENE	C-405-270P
C409,410	CAP, .15UF,20%,50V, CERAMIC	C-418-.15
C412	CAP, 1UF, 20%, 35V, TANTALUM	C-494-1
C501,503	CAP, 47UF, 20%, 100V ALUM ELEC	C-521-47
C502,504-506,550-553	CAP, .01U, 10%, 500V CERAMIC	C-497-.01
C512,514	CAP, 22PF, 10%, 100V, CERAMIC	C-451-22P

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
C513	CAP,560PF,2.5%,630V,POLYPROPYLENE	C-405-560P
C515,541	CAP,.1UF, 20%,50V,CERAMIC	C-418-.1
C522,523,526,527	CAP, 3300P, 10%, 500V, CERAMIC	C-497-3300P
C528,533	CAP, 3300P, 10%, 500V, CERAMIC	C-497-3300P
C534,535	CAP, 470UF, 20%, 63V ALUM ELEC	C-477-470
C537-540	CAP, .1UF, 20%,100V, CERAMIC	C-436-.1
C542,548,549,561,564	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C543	CAP,10PF,10%,1000V,CERAMIC	C-64-10P
C544-547	CAP, .01U, 10%, 500V CERAMIC	C-497-.01
C558,565,566,600-602,605-607,613,614,617	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C610,612	CAP, 2200P, 10%, 100V CERAMIC	C-430-2200P
C616,556,557,559,560,562,563	CAP, 22UF, 20%, 25V, TANTALUM	C-440-22
C618-625,650-652,659-662,262,263	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
CR200-203,205,207,208,210,216-221,235	DIODE, SWITCHING, MMBD914	RF-83
CR206,209,230-233,400,401,222,223	DIODE,IN3595	RF-43
CR224,225,517,519	SCHOTTKY BARRIER RECTIFIER	RF-119
CR236,602,212,213,518,522,204,211,239	DIODE, SWITCHING, MMBD914	RF-83
CR237	DIODE, DUAL SWITCHING, BAV99L	RF-82
CR520,521	ULTRAFAST POWER RECTIFIER	RF-105
CR600	DIODE, DUAL HSM-2822T31	RF-95
CR601	DIODE, SCHOTTKY, SD103C	RF-113
HS1-HS5,400	HEAT SINK	HS-38
J1027	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-16
J1028	CONNECTOR, HEADER STRAIGHT SOLDER PIN	CS-368-14
J1029	CONN, MALE, 5-PIN (MOLEX 42491)	CS-784-5
J1034	LATCHING HEADER,FRICTON, SGL ROW	CS-724-3

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
K200-205	N.C RELAY, 1 FORMB, AQV214S	RL-176
K206,207,208	RELAY	RL-207
K211	RELAY, SURFACE MOUNT	RL-188
L201,500,501	CHOKE, SHIELD BEAD	CH-52
L600,601,602	FERRITE CHIP 600 OHM BLM32A07	CH-62
L603	FERRITE CHIP 600 OHM BLM32A07	CH-62
Q200-207,240,241	TRANS, N CHANNEL JFET, SNJ132199	TG-294
Q208,210,212,214,216,218	TRANS,NPN CATV SILICON,MPSH17	TG-221
Q209,211,213,215,217,219	TRANS,CURRENT REGULATOR,CR430	TG-219
Q220,225	TRANS,NPN SILICON,MJE340	TG-209
Q221,226	TRANS,PNP POWER,MJE350	TG-210
Q222,224	TRANS, N-CHAN JFET, SST4393	TG-263
Q234-239,244,246,255,256, 258,401,404,229	TRANS, N-MOSFET, VN0605T	TG-243
Q242,243	TRANS, N-CHAN MOSFET, TN254ON8	TG-274
Q247,520,601,529,228,248	TRANS, PNP, MMBT3906L	TG-244
Q249	TRANS, NPN SILICON, BC846BL	TG-278
Q250	TRANS PNP, BC 856BL	TG-287
Q402,409	TRANS, N-CHAN DMOS FET TN2504N8	TG-261
Q403,406,407,408	TRANS, N-CHAN JFET, SST109	TG-266
Q405,410,411,602-605,223,420,502	TRANS, N-MOSFET, VN0605T	TG-243
Q412,414	TRANS, N-MEGAFET, RFD 14N05LSM	TG-267
Q415,416	TRANS, P-FET, MTP23P06	TG-229
Q417,419	N CHANNEL MEGAFET	TG-339
Q418	TRANS, P-CHAN, MOSFET, TP0610T	TG-259
Q500,503	TRANSISTOR, SMT	TG-350
Q501,510,534,535,528,227,257,515, 517,519	TRANS, NPN, MMBT3904	TG-238
Q504,514,516	TRANSISTOR	TG-349
Q507,523,525	TRANSISTOR	TG-348
Q518	TRANSISTOR	TG-356

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
Q521	TRANSISTOR	TG-357
Q522,524,600	TRANS, NPN, MMBT3904	TG-238
Q526,527,530,531	TRANS, N CHANNEL MOSFET, SI9410DY	TG-302
Q532	TRANS,N-CHANNEL FET,IRF630	TG-214
Q533	TRANS,P-CHANNEL 200V FET,IRF9630	TG-215
R117-128,133-136,141-144	RES, 10K, 5%, 250MW, METAL FILM	R-376-10K
R129,211,224-229,234237,244,247,281,282	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R137-140,145-149	RES, 10K, 5%, 250MW, METAL FILM	R-376-10K
R150,151,389,390,431,432,433,434,520,536	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R152,291,293	RES, 42.7K, .1%, .125W,THIN FILM	R-456-42.7K
R155,669	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R200,201,203,232,238	RESISTOR NETWORK, 10K-10K	TF-236
R202,204,252,255,256,259,260,263,264,267	RES, 100K, 1%, 100MW THICK FILM	R-418-100K
R205,310,485,552,667	RES, .0499, 1%, 100MW, THICK FILM	R-418-.0499
R207	RES, 20K, .1%, .125W THIN FILM	R-456-20K
R210,208	RES, 768, 1%, 100MW, THICK FILM	R-418-768
R212	RES, 332, 1%, 100MW, THICK FILM	R-418-332
R213	RES NET 5K, .1%, 668A	TF-243-5K
R216,221,274-279,223	RES, 20K, 1%, 100MW THICK FILM	R-418-20K
R217,500,515	RES, 121K, 1%,100MW, THICK FILM	R-418-121K
R218	RES, 80.6K, 1%, 100MW THICK FILM	R-418-80.6K
R219,220,222,230,231,373,374,616,700,701	RES, 49.9K, 1%, 100MW THICK FILM	R-418-49.9K
R240,243,248,251,253,254,257,258,261,262	RES, 4.99K, 1%, 100MW THICK FILM	R-418-4.99K
R241,242,249,250,653,664	RES, 140K, 1%, 100MW THICK FILM	R-418-140K
R265,266,311-317,334,335,337,339,357,366	RES, 4.99K, 1%, 100MW THICK FILM	R-418-4.99K
R268-271,209	RES, 1M, 1%, 100MW, THICK FILM	R-418-1M

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
R272,273,346-348,511,512	RES, 249K, 1%, 100MW, THICK FILM	R-418-249K
R280	RES,4.02K,1%,100MW, THICK FILM	R-418-4.02K
R283,287,297,299,349,350-352,457,461	RES, 30.1K, 1%, 100MW, THICK FILM	R-418-30.1K
R284-286,288,301,358,504, 617,622,654,655	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R289,303	RES, 20K, .1%, .125W THIN FILM	R-456-20K
R292,338,527,528,533,535,544, 546,547	RES, 100K, 1%, 100MW THICK FILM	R-418-100K
R294-296	RES, 100K, .1%, .125W, THIN FILM	R-456-100K
R298,300,345	RES, 150K, 1%, 100MW, THICK FILM	R-418-150K
R302,525,526	RES, .0499, 1%, 100MW, THICK FILM	R-418-.0499
R308	RES, 1.5K, 1%, 100MW THICK FILM	R-418-1.5K
R332,423,429,430,604,606	RES, 499, 1%, 100MW THICK FILM	R-418-499
R340,343,361,362,365,369,336,353, 481	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R341,342,505	RES, 13K, 1%, 100MW, THICK FILM	R-418-13K
R354,437	RES, 560K, 5%, 250MW, METAL FILM	R-376-560K
R363	RES NET, .1%, .1W	TF-259
R364,370,371,372,402,403,404,416, 417,459	RES, 100K, 1%, 100MW THICK FILM	R-418-100K
R367,424,425,426,601,603,605,608,626,702	RES, 4.99K, 1%, 100MW THICK FILM	R-418-4.99K
R368	RES, 332, 1%, 100MW, THICK FILM	R-418-332
R375,376	RES, 10, 10%, 100MW, THICK FILM	R-418-10
R379-387,391,392	RES, 475, 1%, 100MW, THICK FILM	R-418-475
R393-399,411,412,413,388,307	RES, 357, 1%, 100MW, THICK FILM	R-418-357
R422	RES, 4.7K, 5%, 250MW, METAL FILM	R-376-4.7K
R435,436	RES, 499, 1%, 100MW THICK FILM	R-418-499
R450	RES, 200K, .1%, 1/10W METAL FILM	R-263-200K
R452	RES, 21.93K, .1%, 1/10W METAL FILM	R-263-21.93K
R453	RES,1.82K,.1%,1/10W,METAL FILM	R-263-1.82K

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
R454,455,469,470,471,467,468	RES, 100, .1%, 1/10W, METAL FILM	R-263-100
R463,479,473	RES, 30.1K, 1%, 100MW, THICK FILM	R-418-30.1K
R472,478,466,355,290,344,309	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R474	RESISTOR	R-473-.2
R482,484,487	RES, 6.04K, 1%, 100MW THICK FILM	R-418-6.04K
R483	RES, 2K, 1%, 100MW, THICK FILM	R-418-2K
R488,562,600	RES, 100K, 1%, 100MW THICK FILM	R-418-100K
R489,356,359,418-421,456,458,460,462	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R490	RES, 205, .1%, 1/10W, METAL FILM	R-263-205
R501,514,570,571,705	RES, 249,1%, 100MW, THICK FILM	R-418-249
R503,563	RES, 15k, 1%, 100MW, THICK FILM	R-418-15K
R506,507	RES, 11K, 5%,250MW,METAL FILM	R-376-11K
R508,509	RES, 11K, 5%,250MW,METAL FILM	R-376-11K
R516,523	RES,4.02K,1%,100MW, THICK FILM	R-418-4.02K
R517,524,564,565,566,567	RES, 12.1, 1%, 125MW METAL FILM	R-391-12.1
R521	RES, 2M, 1%, 100MW, THICK FILM	R-418-2M
R529,530,532,534	RES, 249,1%, 100MW, THICK FILM	R-418-249
R537,451,531	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R538-543,568,569	RES,.5,5%,1W, METAL	R-444-.5
R545	RES, 15k, 1%, 100MW, THICK FILM	R-418-15K
R548,304-306	RES, 33, 5%, 250mW, METAL FILM	R-376-33
R554	RES, 2.21K, 1%, 100MW, THICK FILM	R-418-2.21K
R559	RES, 100, 1%, 100MW, THICK FILM	R-418-100
R560,561	RES, 45.3K, 1%, 100MW THICK FILM	R-418-45.3K
R602,607	RES, 150, 5%, 250MW, METAL FILM	R-376-150
R609	RES NET	TF-245
R610	RES, 1.28M, .1%, 1/8W METAL FILM	R-176-1.28M
R611,621	RES, 475, 1%, 100MW, THICK FILM	R-418-475
R612	RES, 5.11K, 1%, 100MW, THICK FILM	R-418-5.11K
R613,624,659,660,558	RES, 100, 1%, 100MW, THICK FILM	R-418-100

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
R614,615,553	RES, 2.21K, 1%, 100MW, THICK FILM	R-418-2.21K
R618	RES, 34K, 1%, 100MW, THICK FILM	R-418-34K
R619	RES, 4.75K, 1%, 100MW, THICK FILM	R-418-4.75K
R620	RES, 82.5, 1%, 100MW, THICK FILM	R-418-82.5
R623	RES, 10, 10%, 100MW, THICK FILM	R-418-10
R650,651	RES NET, 9K-1K, MICRO DIVIDER	TF-246-2
R652,665	RES, 357, 1%, 100MW, THICK FILM	R-418-357
R656	RES, 6.04K, .1%, .125W THIN FILM	R-456-6.04K
R657,658	RES, 1M, 1%, 100MW, THICK FILM	R-418-1M
R666	RES NET, 3K, 12K, 0.1%, 100MW THIN-FILM	TF-237-2
R703,153,154	RES, 4.99K, 1%, 100MW THICK FILM	R-418-4.99K
R704,706,707,502,510	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R710	RESISTOR	R-474-.065
RT200	POLYSWITCH, PTC RESISTOR	RT-17
RT500	THERMISTER, PD=7MW/DEG C, 1500V,613.74K	RT-8
TP218-225	CONN,TEST POINT	CS-553
TP500-510,TP227,228,230-235,200-215	CONN,TEST POINT	CS-553
U202,650,203	IC, OP AMP LT1112	IC-1048
U204,229	IC, 8-CHAN ANA MULTI-PLEXER,DG408DY	IC-844
U205,407	IC, HEX INVERTERS, 74HCT04	IC-880
U209,215	IC, QUAD COMPARATOR,LM339D	IC-774
U210,220	IC, DUAL BIPOLAR OP-AMP, LT1124CS8	IC-955
U211,213	IC, BIFET OP AMP, AD712JR	IC-834
U212,214,230,241,400-406,652	IC, CMOS ANAL SWITCH, DG444DY	IC-866
U221,227	IC, DIFF. AMP, AMP03GP	IC-988
U222	IC, OP-AMP, LTC1050CS8	IC-791
U223,411,507,508	IC, MOSFET DRIVER, TLP591B	IC-877
U226,659	IC, 20V OP-AMP, LT1097S8	IC-767

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
U228,263	IC, OP-AMP, LOW NOISE LT1007CS8	IC-949
U231,219,235,234,262	IC, OP AMP, LOW POWER AD795JR	IC-1052
U238,201	IC, CMOS ANA SWITCH SPST MAX326CSE	IC-909
U239	IC, QUAD 2-INPUT NAND, 74HC00M	IC-781
U240	IC,POS NAND GATES/INVERT,74HCT14	IC-656
U242-247	IC,DUAL HIGH CMR/SPEED OPTO,HCPL-2631	IC-588
U252-256	IC 8 STAGE SHIFT CD74HC4094M	IC-1026
U257	IC, SUPPLY VOLT SUPERVISOR, TL7705A	IC-860
U410,218,216,225	ICM DUAL J-FET OP-AMP, OP-282GS	IC-968
U500	IC, OP-AMP, AD847JN	IC-890
U501,506	IC, VOLT COMPARATOR LM393D	IC-775
U503	IC,+5V VOLTAGE REGULATOR, LM2940CT	IC-576
U504	IC,POS VOLTAGE REG+15V,500MA,78M15	IC-194
U505	IC,NEG VOLTAGE REG -15V, 500MA,79M15	IC-195
U600,264,206,207,208,233	IC, DUAL PICOAMP OP-AMP AD706JR	IC-910
U601	IC, QUAD D FLIP FLOP W/CLK,RESET 74HC175	IC-923
U604	IC, NCHAN LAT DMOS QUAD-FET,SD5400CY	IC-893
U605	INTEGRATED CIRCUIT, OPA17	IC-960
U606,236	IC, HI-SPEED BIFET OP-AMP, AD711JR	IC-894
U607	IC, OP-AMP, NE5534D	IC-802
U608	IC, VOLT. COMPARATOR,LM311M	IC-776
U609	PROGRAMMED IC	2400-801-*
U651,602,603,224	IC, QUAD 2 IN NOR, 74HCT02	IC-809
U660,661	IC, 16 BIT DAC, AD7849BR	IC-1004
VR200,201	DIODE, ZENER MM524694 TI	DZ-113

Table 6-1 (cont.)
Analog board parts list

Circuit designation	Description	Keithley part no.
VR202,203,407-409,506,507	DIODE,ZENER 5.1V, BZX84C5V1	DZ-88
VR214,215	DIODE, ZENER, 8.2V, MMBZ5237	DZ-92
VR400,401	DIODE, ZENER 4.7V, IN4732A	DZ-67
VR410,601,604	DIODE, ZENER 3.3V, MMBZ5226BL	DZ-94
VR500,501	DIODE, ZENER 6.0V, BZX84B6V2	DZ-87
VR502,503	DIODE ZENER 12V, MMSZ12T1	DZ-112
VR600	DIODE,ZENER 6.4V,IN4579	DZ-73
VR602,603	DIODE, ZENER, 6.2V MMSZ6V2	DZ-97
Y600	OSCILLATOR HIGH SPEED CMOS 12MHZ	CR-37

Table 6-2
Digital board parts list

Circuit designation	Description	Keithley part no.
BT1	BATTERY	BA-46
C1,3,77,11,14,16,17,20,22,23,25,26,30	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C103	CAP, 100UF, 20%, 10V, ALUM ELEC	C-483-100
C104	CAP,10UF,20%,63V,ALUM ELEC	C-403-10
C105,108,109,111	CAP, 47UF, 20%, 100V ALUM ELEC	C-521-47
C107,110	CAPACITOR, ALUM ELEC	C-554-82
C113,115,117,119	CAPACITOR SMT	C-551-10
C114	CAP,100UF,20%,63V,ALUM ELEC	C-403-100
C116	CAP, 100UF, 20%, 16V ALUM ELEC	C-530-100
C120	CAP, 270PF, 5%, 100V, CERAMIC	C-465-270P
C121	CAP, 390P, 10%, 100V, CERAMIC	C-451-390P
C122	CAP, .47U, 20%, 25V	C-520-.47
C19,69,85,75,92	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C2,56,76,78,8,80,82,87,88,89,44,46	CAP, .01UF, 10%, 50V CERAMIC	C-491-.01
C24,96	CAPACITOR, POLYESTER	C-553-.1
C27,32,34,36	CAP, 1UF, 20%, 50V CERAMIC	C-519-1
C28	CAP, 47P, 5%, 100V, CERAMIC	C-465-47P
C31,50	CAP,100PF, 5%, 100V, CERAMIC	C-465-100P
C33,63,74,93	CAP, .047U, 10%, 50V, CERAMIC	C-491-.047
C35	CAP, 22UF, 20%, 25V, TANTALUM	C-440-22
C39,41,42,49,59,66-68,79,81,48,83	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C4,10	CAP, 15P, 1%, 100V CERAMIC	C-512-15P
C43	CAP,.33UF,10%, 50V CERAMIC	C-464-.33
C5	CAP, .1UF, 20%,100V, CERAMIC	C-436-.1
C51	CAP,33PF,10%,1000V,CERAMIC	C-64-33P
C54,60,45,53	CAPACITOR	C-527-5000P
C55,15,21,29,37	CAP, .01, 5%, 50V, NPO	C-514-.01
C57,58,38	CAP, 1000PF,10%, 50V, MONO CERAMIC	C-452-1000P
C62,91	CAP, 10UF,20%, 25V, TANTALUM	C-440-10
C65	CAP, .022UF, 10%, 50V CERAMIC	C-491-.022
C72,86	CAP, 1UF, 20%, 50V CERAMIC	C-519-1

Table 6-2 (cont.)
Digital board parts list

Circuit designation	Description	Keithley part no.
C84,6,7,9,18,90,52,70,71,73,64,102	CAP, .1UF, 10%, 25V, CERAMIC	C-495-.1
C94	CAP, 470UF, -20+100%, 16V ALUMINUM	C-313-470
C96,106,112,118	CAP, 22UF, -10+100%, 35v ELECTRO-LYTIC	C-309-22
C97	CAPACITOR, POLYESTER	C-553-.47
C99	CAP, .01uF, 20%, 50V, CERAMIC	C-418-.01
CR13	DIODE, DUAL HSM-2822T31	RF-95
CR14,15,22-24,5,32,33	DIODE, DUAL SWITCHING, BAV99L	RF-82
CR1-4,35,37,38,39,47	ULTRAFAST POWER RECTIFIER	RF-107
CR36,43,44,45,46	DIODE, ULTRAFAST, MUR860	RF-68
CR48,49	DIODE, SWITCHING, MMBD914	RF-83
CR6,12,40,41	ULTRAFAST POWER RECTIFIER	RF-105
CR8,11,17,21,25-28,31,19	DIODE, SWITCHING, 250MA,BAV103	RF-89
CR9	RECTIFIER	RF-120
F1	POLYSWITCH, SMD030-2	FU-103
F2	FUSE, 3A	FU-107-1
HS1,2	HEAT SINK	HS-38
J1002	CONN, MOLEX, 3-PIN	CS-772-3
J1023	CONN,RIGHT ANGLE,24PIN	CS-507
J1024	CONN, RT ANGLE, MALE, 9 PIN	CS-761-9
J1025	CONN, MICRODIN W/GND FINGERS	CS-792
J1026	CONN, D-SUB MALE, BOARDLOCK TYPE	CS-848-9
K1	RELAY, SURFACE MOUNT	RL-188
L1	FERRITE CHIP 600 OHM BLM32A07	CH-62
L3	CHOKE	CH-81
L4,5,6,7	CHOKE	CH-89-1
LS1	BEEPER, 5V, 30MA, QMX-05	EM-6
P1027,1033	CABLE ASSEMBLY	CA-62-4B
P1028	CABLE ASSEMBLY	CA-32-9B

Table 6-2 (cont.)
Digital board parts list

Circuit designation	Description	Keithley part no.
P1035	LATCHING HEADER,FRICTON, SGL ROW	CS-724-3
PS1	POWER SUPPLY	PS-54-2A
Q1,3,4,5,6	TRANS, N-MOSFET, VN0605T	TG-243
Q10	TRANS, NPN, MMBT3904	TG-238
Q2	TRANSISTOR	TG-338
Q7,12,8	POWER MOSFET IRFZ346	TG-313
Q9	TRANS,TRIODE THYRISTOR,MAC223A6	TG-172
R1,37,43,44,45	RES, 2.21K, 1%, 100MW, THICK FILM	R-418-2.21K
R10	RES, 332K,1%, 100MW, THICK FILM	R-418-332K
R101	RES, 20K, 1%, 100MW THICK FILM	R-418-20K
R102	RES, 100K, 1%, 100MW THICK FILM	R-418-100K
R103,105	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R108,51	RES, 249K, 1%, 100MW, THICK FILM	R-418-249K
R15,17,21,23,31,70,72,18,48,61,8,155	RES, 1K, 1%, 100MW, THICK FILM	R-418-1K
R2,13,4,52,14,19,34,35,50,58,63,68, 62,75	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R22	RES,4.02K,1%,100MW, THICK FILM	R-418-4.02K
R25,28,49	RES, 4.75K, 1%, 100MW, THICK FILM	R-418-4.75K
R30	RES, 100, 1%, 100MW, THICK FILM	R-418-100
R33,39,92,95,29,36,42	RES, .0499, 1%, 100MW, THICK FILM	R-418-.0499
R40,32,27,24	RES, 5.1K,5%, 125MW, METAL FILM	R-375-5.1K
R41,56,96,98	RESISTOR, METAL FILM	R-465-499K
R46	RES, 10, 10%, 100MW, THICK FILM	R-418-10
R5	RES, 10M, 1%, 125MW, THICK FILM	R-418-10M
R55	RES, 10M, 1%, 125MW, THICK FILM	R-418-10M
R57	RES, 1M, 1%, 100MW, THICK FILM	R-418-1M
R59	RES, 475, 1%, 100MW, THICK FILM	R-418-475
R6,47	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R65	RES, 2.21K, 1%, 100MW, THICK FILM	R-418-2.21K

Table 6-2 (cont.)
Digital board parts list

Circuit designation	Description	Keithley part no.
R66	RESISTOR, METAL FILM	R-464-100K
R67	RES, 8.06K, 1%, .1W THICK FILM	R-418-8.06K
R73,74,76,78-81,83,7,60,69,71,85-89	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R77	RES, 15k, 1%, 100MW, THICK FILM	R-418-15K
R82	RES, 499, 1%, 100MW THICK FILM	R-418-499
R84,109,110,38	RES, 10K, 1%, 100MW, THICK FILM	R-418-10K
R9,11,12,16,20	RES,100,5%,250MW,METAL FILM	R-376-100
R90	RESISTOR, THICK FILM	R-418-1.07K
R93	RES, 6.81K, .1%, .125W THIN FILM	R-456-6.81K
R94	RESISTOR, CERAMIC	R-463-.1
R97,100	RES, 200, 1%, 100MW, THICK FILM	R-418-200
R99,107	RES, 150K, 1%, 100MW, THICK FILM	R-418-150K
RT101	INRUSH CURRENT LIMITER	RT-23
RV1	VARISTOR	VR-10
RV101	METAL OXIDE VARISTOR	VR-7
S01,2	SOCKET PLCC-032-T-A	SO-143-32
S1	SWITCH,PUSHBUTTON (6 POLE)	SW-466
T1	TRANSFORMER	TR-313A
T2	TRANSFORMER	TR-312A
T3	TRANSFORMER	TR-317A
TP1-12, 14-18	CONN,TEST POINT	CS-553
U10	LARGE SCALE IC, SMT	IC-980
U11	IC, VOLT COMPARATOR LM393D	IC-775
U12,14	LARGE SCALE IC	LSI-162-70
U13	IC, GPIB ADAPTER, 9914A	LSI-123
U15	PROGRAMMED ROM	2400-803-*
U16	PROGRAM	2400-804-*
U17	IC, SERIAL EPROM 24LC16B	LSI-153
U18	IC, REGULATOR SWITCHING 78ST105SC	IC-1080
U19	IC, SCHMITT-TRIGGER NAND GATE	IC-950

Table 6-2 (cont.)
Digital board parts list

Circuit designation	Description	Keithley part no.
U2	IC, MICROMANAGER, DS12365-10	IC-884
U20	IC,OCTAL INTERFACE BUS,75160	IC-646
U21	IC, DUAL POWER MOSFET DRIVER, TSC426	IC-437
U22	IC, DUAL D-TYPE F/F, 74HC74	IC-773
U23,25	IC,POS NAND GATES/INVERT,74HCT14	IC-656
U24	IC,TRIPLE 3 IN NAND,74F10	IC-659
U26	IC, VOLTAGE REGULATOR, LM340-12	IC-60
U3	MICROCONTROLLER, MC68332-FC	LSI-161
U4	IC +5V RS-232 TRANSCEIVER, MAX202	IC-952
U5	IC, OP-AMP, AD705JR	IC-814
U6	IC,OCTAL INTER BUS TRANS,75161	IC-647
U7	IC, 4-CHANNEL PWR DRIVER, 2549B	IC-1044
U8	INTEGRATED CIRCUIT	IC-1113
U9	IC, HEX INVERTERS, 74HCT04	IC-880
VR1	DIODE, ZENER 33V, IN4752A	DZ-68
Y1	CRYSTAL, FSM327	CR-41

* Order current firmware revision level.

Table 6-3
Display board parts list

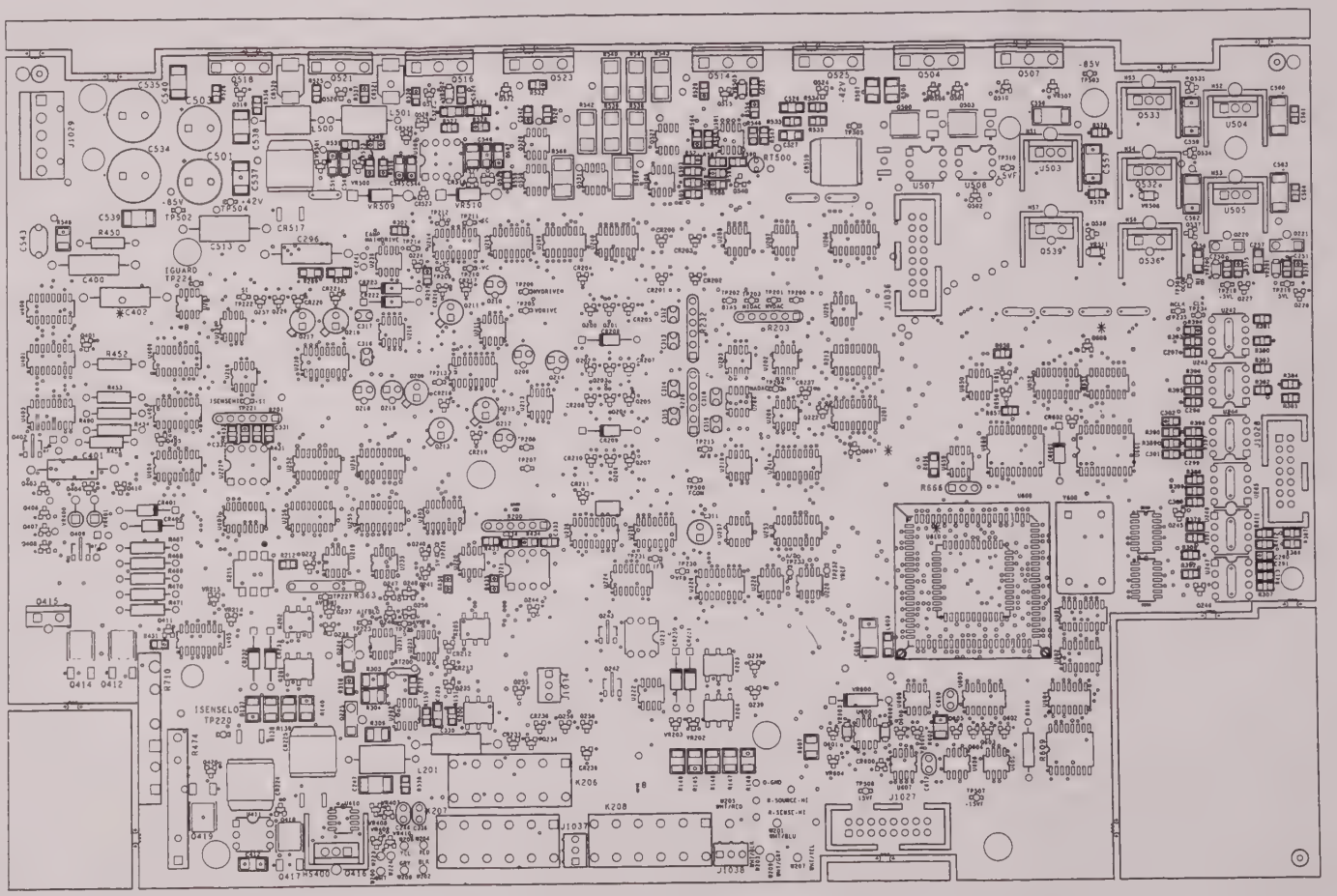
Circuit designation	Description	Keithley part no.
C901	CAP,22UF, 20%, 6.3,TANTALUM	C-417-22
C902,904,907,908,910	CAP, .1UF, 20%,100V, CERAMIC	C-436-.1
C903,905,906,909,911	CAP,.1UF, 20%,50V,CERAMIC	C-418-.1
C912	CAP, 2.2UF, 20%,100V, ALUM ELEC	C-503-2.2
C913,914	CAP,100UF,20%,16V, TANTALUM	C-504-100
C915,916	CAP, 33PF, 10%, 100V, CERAMIC	C-451-33P
CR901-904	DIODE, SWITCHING, 250MA,BAV103	RF-89
CR905,906	DIODE, SWITCHING, MMBD914	RF-83
DS901	VACUUM FLUORESCENT DISPLAY	DD-51C
J1032	CONN,BERG	CS-339
J1033	CONN, HEADER STRAIGHT SOLDER PIN	CS-368-16
Q901,902	TRANS, NPN GEN PURPOSE BC868	TG-293
R901	RES NET, 15K, 2%, 1.875W	TF-219-15K
R902	RES, 13K, 5%,125MW, METAL FILM	R-375-13K
R903,904	RES, 4.7K, 5%, 250MW, METAL FILM	R-376-4.7K
R905	RES, 1M, 5%, 125MW, METAL FILM	R-375-1M
R906	RES,1K, 5% 250MW, METAL FILM	R-376-1K
R907	RES, 240, 5%, 250MW, METAL FILM	R-376-240
R908	RES, 10M, 5%, 125MW, METAL FILM	R-375-10M
T901	TRANSFORMER, TDK, ER14.5 SERIES	TR-300
U901,904,905	IC, LATCHED DRIVERS,UCN-5812EPF-1	IC-732
U902	PROGRAMMED ROM	7001-800-*
U903	IC, 32-BIT, SERIAL UCN5818EPF	IC-830
VR901	DIODE, ZENER, 8.2V, MMBZ5237	DZ-92
Y901	CRYSTAL, 4MHZ	CR-36-4M

*Order same revision level as current part.

Table 6-4
Mechanical parts list

Description	Keithley part no.
FAN	FN-33-2
LINE FILTER	LF-11
LUG	LU-88
LED, HIGH POWER	PL-94
CHASSIS ASSEMBLY	2420-302A
REAR PANEL	2400-303B
CHASSIS	2420-301A
BANANA JACK, PUSH-IN BLACK	BJ-14-0
BANANA JACK, PUSH-IN RED	BJ-14-2
BANANA JACK, PUSH-IN BLUE	BJ-14-6
BANANA JACK, PUSH-IN WHITE	BJ-14-9
HOLDER, FERRITE	2001-367A
PC BOARD STOP	2001-371A
SWITCHPAD	2400-315A
HEAT SINK	2420-308A
BOTTOM SHIELD	2420-309A
DISPLAY LENS	2420-311A
COVER	2420-317A
BEZEL, REAR	428-303D
FOOT	428-319A
MOUNTING EAR, RIGHT	428-328E
HANDLE	428-329F
MOUNTING EAR, LEFT	428-338B
LENS, LED	6517-309A
POWER ROD	704-313A
CHOKE	CH-58-1A
FOOT, EXTRUDED	FE-22A
FOOT,RUBBER	FE-6
FUSE	FU-106-3.15

LTR	ECA NO	REVISION	ENG	DATE
C	19543	REVISED	SZ	1/29/97
D	20029	UPDATED ARTWORK SHOWN	AJS	6/26/97
D1	20645	DEL DO NOT POP NOTES FOR R308,R379 U265,U266 J1036-1038	SZ	9/03/97
E	20401	Increased width of heat sinks Moved Q416 away from edge Added U610 to NO-POP list		12/4/98



FOR COMPONENT INFORMATION SEE PRODUCT STRUCTURE

COMPONENT SIDE (view from component side)

(PTH)
* DO NOT POPULATE
C402

(SMT)
* DO NOT POPULATE
Q606,Q607,U610

MODEL	NEXT ASSEMBLY	QTY
USED ON		

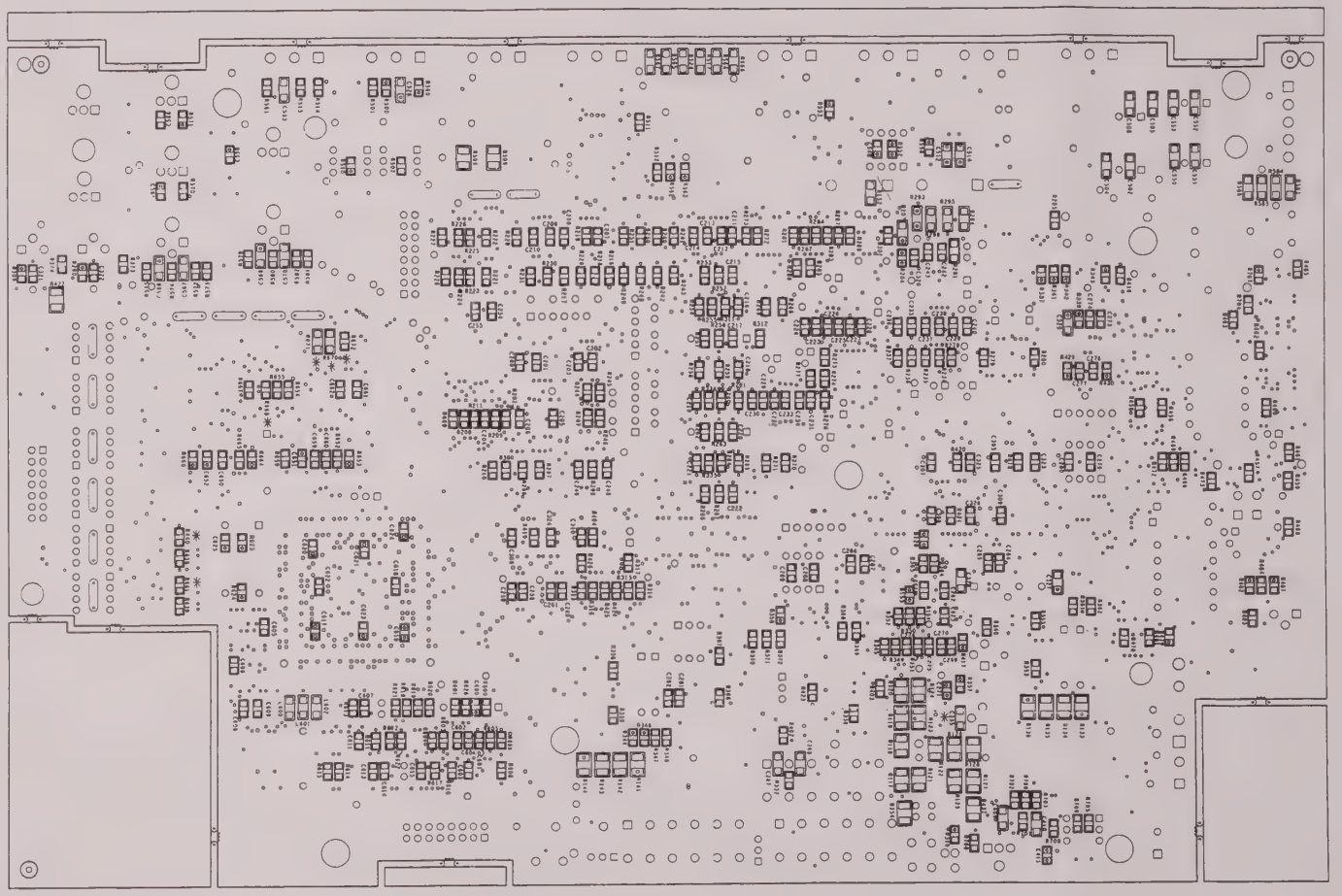
KEITHLEY KEITHLEY INSTRUMENTS INC CLEVELAND, OHIO 44139	DIM ARE IN IN. UNLESS OTHERWISE NOTED DIM TOL UNLESS OTHERWISE SPECIFIED XX±.01 ANG ±1 XXX±.005 FRAC ±1/64	DATE 9/23/98 DRN MS APPR. PS DO NOT SCALE THIS DRAWING	SCALE 3:2 C

TITLE COMPONENT LAYOUT DRAWING
2420 HI CURRENT
ANALOG BOARD

NO 2420-100

ORIGINAL IF MED

LTR.	ECA NO	REVISION	ENG	DATE
C	19543	REVISED	SZ	1/29/97
D	20029	UPDATED ARTWORK SHOWN	AJS	6/26/97
D1	20645	ADD NO POP TO R440 & R441 DEL NO POP TO R438 & R439	SZ	9/03/97
E	20401	See Pg. 1		10/98



(SMT)
* DO NOT POPULATE
C335 R440 R441
R669 R670 R671 R672

FOR COMPONENT INFORMATION SEE PRODUCT STRUCTURE

SOLDER SIDE COMPONENTS (view from solder side)

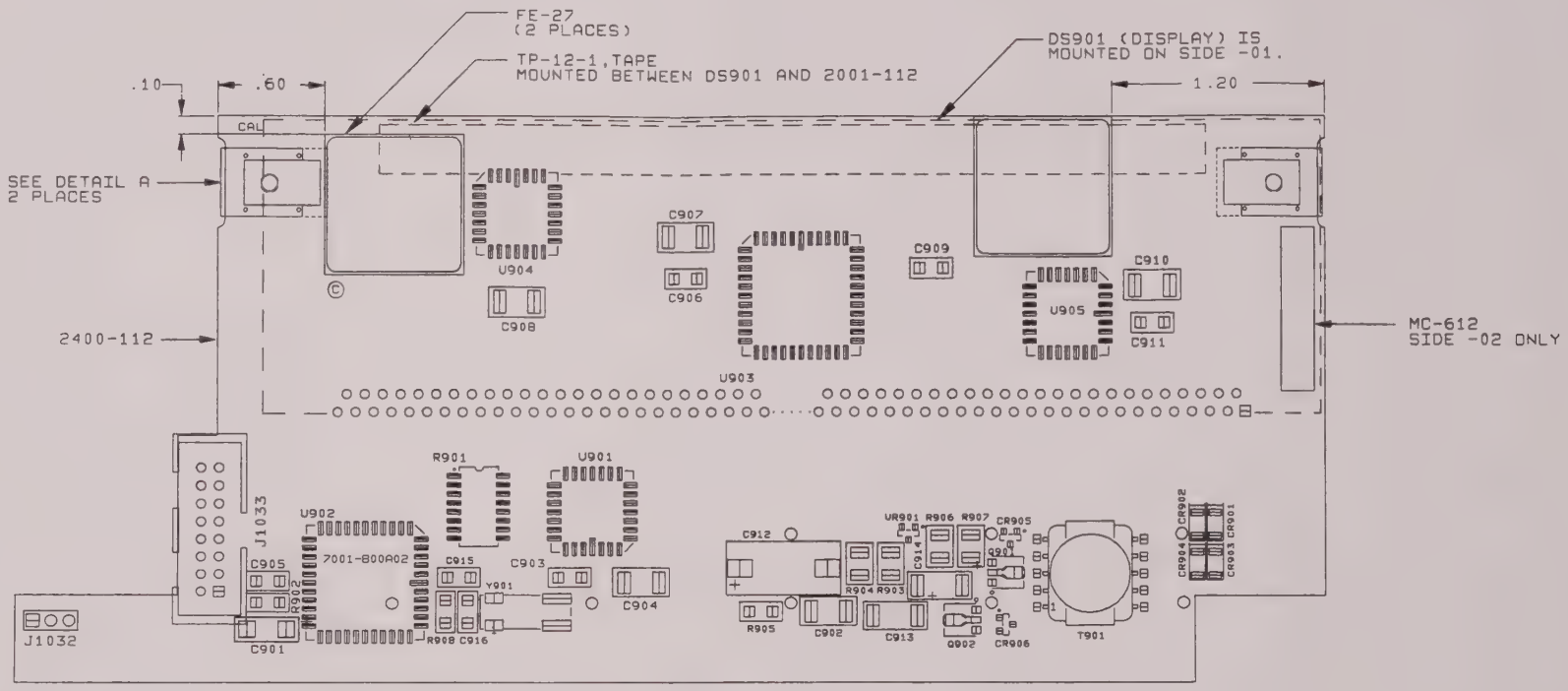
MODEL	NEXT ASSEMBLY	QTY
USED ON		

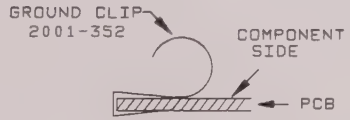
KEITHLEY KEITHLEY INSTRUMENTS INC CLEVELAND, OHIO 44139	DIM ARE IN IN UNLESS OTHERWISE NOTED DIM TOL UNLESS OTHERWISE SPECIFIED XX±.01 ANG.±1 XXX±.005 FRAC ±1/64	DATE 9/23/98 DRN MS APPR PS DO NOT SCALE THIS DRAWING	SCALE 3:2 TITLE COMPONENT LAYOUT DRAWING 2420 HI CURRENT ANALOG BOARD C NO 2420-100

ORIGINAL IF RED PG 2 OF 2

2400-110 ON

LTR.	ECO NO.	REVISION	ENG.	DATE
A	17908	RELEASED	SZ	10-25-95
C	20811	CHG'D ARTWORK FROM REV A TO C.		1-29-98





DETAIL A

NOTE: FOR MORE COMPONENT INFORMATION REFER TO 2400 PRODUCT STRUCTURE.

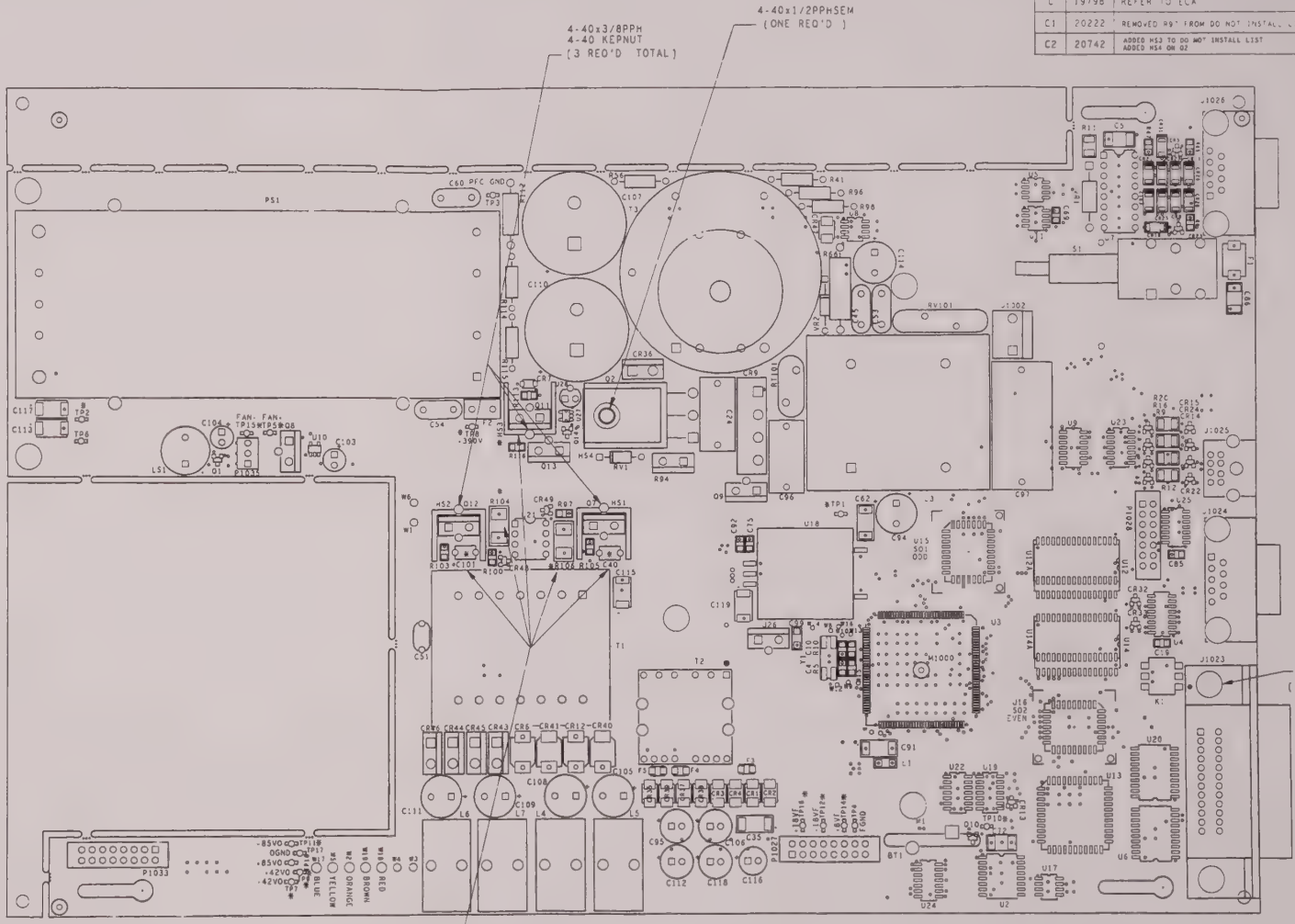
2400		1
MODEL	NEXT ASSEMBLY	QTY.
USED ON		

DO NOT SCALE THIS DRAWING	DIMENSIONAL TOLERANCES UNLESS OTHERWISE SPECIFIED	DATE 6/22/95	SCALE 3:2	TITLE	COMPONENT LAYOUT, DISPLAY BOARD
	XX=±.010 ANG.=±1°	DRN. AJS	ENG. APPR. AJC		
KEITHLEY KEITHLEY INSTRUMENTS INC. CLEVELAND, OHIO 44139	XXX=±.005 FRAC.=±1/64	MATERIAL		B	NO. 2400-110
	SURFACE MAX. 63	FINISH			

ORIGINAL

2420-140

LTR.	ECA NO.	REVISION	ENG.	DATE
B	19484	RELEASED	SZ	1/13/97
C	19798	REFER TO ECA	AJS	6.26.97
C1	20222	REMOVED R97 FROM DO NOT INSTALL LIST	SZ	8.22.97
C2	20742	ADDED HS3 TO DO NOT INSTALL LIST ADDED HS4 ON Q2		12-29-97



NOTE FOR COMPONENT INFORMATION, REFER TO 2420 PRODUCT STRUCTURE

* DO NOT INSTALL THE FOLLOWING PARTS.
C40,C101,R104,R106
TP1,TP2,TP5,TP7,TP8,TP9,TP10 TP11,TP12,
TP14,TP15,TP16,TP18
HS3

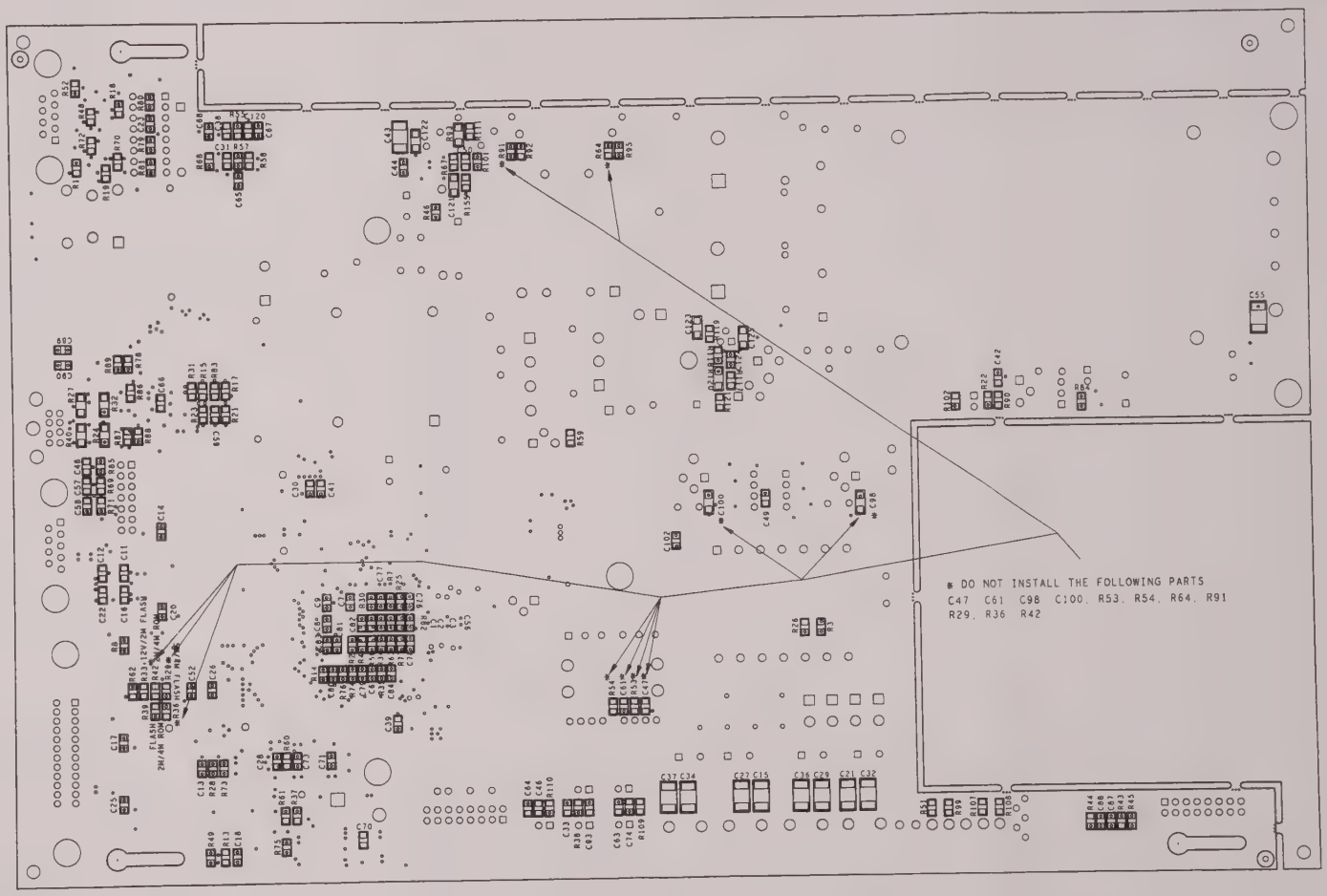
TOP SIDE COMPONENTS (top view)

MODEL	NEXT ASSEMBLY	QTY
USED ON		

KEITHLEY KEITHLEY INSTRUMENTS INC CLEVELAND, OHIO 44139	DIM ARE IN IN UNLESS OTHERWISE NOTED DIM TOL. UNLESS OTHERWISE SPECIFIED XX=±.01 ANG =±1 XXX=±.005 FRAC =±1/64	DATE 12/18/97 DRN KEK DO NOT SCALE THIS DRAWING	SCALE 3/2 APPR.	TITLE COMPONENT LAYOUT 2420 SMU DIGITAL BOARD C NO. 2420-140

2420-140

LTR	EC# NO	REVISION	ENG	DATE
B	19484	RELEASED	BZ	1/13/97
C	19798	REFER TO ECA	AJS	6/26/97
C1	20222	ADDED R29, R36, R42 TO NO POP LIST		8-22-97
C2	[illegible]	SEE PAGE 1		12-24-97



BOTTOM SIDE COMPONENTS (bottom view)

NOTE FOR COMPONENT INFORMATION, REFER TO 2420 PRODUCT STRUCTURE

MODEL	NEXT ASSEMBLY	QTY.
	USED ON	

KEITHLEY
KEITHLEY INSTRUMENTS INC
CLEVELAND, OHIO 44139

DIM ARE IN IN UNLESS OTHERWISE NOTED
DIM TOL UNLESS OTHERWISE SPECIFIED
XX± .01 ANG ±1
XXX± .005 FRAC ±1/64
DO NOT SCALE THIS DRAWING

DATE 1/13/97 SCALE 3:2
DRN KEK APPR

TITLE COMPONENT LAYOUT
2420 SMU
DIGITAL BOARD

C NO 2420-140

A
Specifications

SOURCE SPECIFICATIONS[1]

Voltage Programming Accuracy (remote sense)

Range	Programming Resolution	Accuracy (1 Year) 23°C ±5°C ±% rdg. + volts	Noise (peak-peak) 0.1Hz – 10Hz
200.000 mV	5 µV	0.02% + 600 µV	10 µV
2.00000 V	50 µV	0.02% + 600 µV	50 µV
20.0000 V	500 µV	0.02% + 2.4 mV	500 µV
60.0000 V	1.5mV	0.02% + 7.2 mV	1500 µV

TEMPERATURE COEFFICIENT (0°–18°C & 28°–50°C): ±(0.15 × accuracy specification)/°C.

MAX. OUTPUT POWER: 66W (four quadrant source or sink operation).

SOURCE/SINK LIMITS: 5% over nominal for current and voltage.

VOLTAGE REGULATION: Line: 0.01% of range. **Load:** 0.01% of range + 100µV.

NOISE 10Hz–1MHz (p-p): 15mV maximum, resistive load.

OVER VOLTAGE PROTECTION: User selectable values, 5% tolerance. Factory default = 36 volts.

CURRENT LIMIT: Bipolar current limit (compliance) set with single value. Min. 0.1% of range.

OVERSHOOT: <0.1% typical (full scale step, resistive load, 10mA range).

Current Programming Accuracy (local or remote sense)

Range	Programming Resolution	Accuracy (1 Year) 23°C ±5°C ±% rdg. +amps	Noise (peak-peak) 0.1Hz – 10Hz
10.0000 µA	500 pA	0.033% + 2 nA	50 pA
100.000 µA	5 nA	0.031% + 20 nA	500 pA
1.00000 mA	50 nA	0.034% + 200 nA	5 nA
10.0000 mA	500 nA	0.045% + 2 µA	50 nA
100.000 mA	5 µA	0.066% + 20 µA	500 nA
1.00000 A[2]	50 µA	0.067% + 900 µA	50 µA
3.00000 A[2]	150 µA	0.059% + 2.7mA	150 µA

TEMPERATURE COEFFICIENT (0°–18°C & 28°–50°C): ±(0.15 × accuracy specification)/°C.

MAX. OUTPUT POWER: 66W (four quadrant source or sink operation).[2]

SOURCE/SINK LIMITS: ±1.05A @ 63V, ±3.15A @ 21V.

CURRENT REGULATION: Line: 0.01% of range. **Load:** 0.01% of range + 100pA.

VOLTAGE LIMIT: Bipolar voltage limit (compliance) set with single value. Min. 0.1% of range.

OVERSHOOT: <0.1% typical (1mA step, R_L = 10kΩ, 20V range).

[1] Specifications valid for continuous output currents below 105mA. For operating above 105mA on the 1A range for >1 minute, derate accuracy 10%/100mA above 105mA. For operating above 105mA on the 3A range for >1 minute, derate accuracy 10%/300mA above 105mA.

[2] Full power source operation regardless of load to 30°C. Above 30°C and/or power sink operation, refer to the Power Equations section of the User's Manual.

ADDITIONAL SOURCE SPECIFICATIONS

TRANSIENT RESPONSE TIME: 30µs typical for the output to recover to its spec. following a step change in load. Resistive load.

COMMAND PROCESSING TIME: Maximum time required for the output to begin to change following the receipt of :SOURce:VOLTage|CURRent <nrf> command. **Autorange On:** 10ms. **Autorange Off:** 7ms.

OUTPUT SETTLING TIME: Time required to reach 0.1% of final value after command is processed. 100µs typical. Resistive load. 10µA to 100mA range.

OUTPUT SLEW RATE: 0.14V/µs, 60V range, 100mA compliance. 0.08V/µs, 2V, and 20V ranges, 100mA compliance.

COMMON MODE VOLTAGE: 250VDC.

REMOTE SENSE: Up to 1V drop per load lead.

COMPLIANCE ACCURACY: For Source mode, add 0.1% of range to base specification. For Sink mode, 10µA to 100mA range, accuracy is ±(0.5% + offset*3). For Sink mode, 1A and 3A ranges, accuracy is ±(1.5% + offset*3).

OVER TEMPERATURE PROTECTION: Internally sensed temperature overload puts unit in standby mode.

RANGE CHANGE OVERSHOOT: Overshoot into a fully resistive 100kΩ load, 10Hz to 1MHz BW, adjacent ranges: (100mV) typical, except 20V/60V range boundary.

MINIMUM COMPLIANCE VALUE: 0.1% of range.

MEASURE SPECIFICATIONS [1, 2]

Voltage Measurement Accuracy (remote sense)

Range	Max. Resolution	Input Resistance	Accuracy (23°C ± 5°C) 1 Year, ±(%rdg + volts)
200.000 mV	1 µV	>10GΩ	0.012% + 300 µV
2.00000 V	10 µV	>10GΩ	0.012% + 300 µV
20.0000 V	100 µV	>10GΩ	0.015% + 1 mV
60.0000 V	300 µV	>10GΩ	0.015% + 3 mV

TEMPERATURE COEFFICIENT (0°–18°C & 28°–50°C): ±(0.15 × accuracy specification)/°C.

Current Measurement Accuracy (local or remote sense)

Range	Max. Resolution	Voltage Burden [3]	Accuracy (23°C ± 5°C) 1 Year, ±(%rdg + amps)
10.0000 µA	100 pA	< 1mV	0.027% + 700 pA
100.000 µA	1 nA	< 1mV	0.025% + 6 nA
1.00000 mA	10 nA	< 1mV	0.027% + 60 nA
10.0000 mA	100 nA	< 1mV	0.035% + 600 nA
100.000 mA	1 µA	< 1mV	0.055% + 6 µA
1.00000 A	10 µA	< 1mV	0.060% + 570 µA
3.00000 A	30 µA	< 1mV	0.052% + 1.71mA

TEMPERATURE COEFFICIENT (0°–18°C & 28°–50°C): ±(0.1 × accuracy specification)/°C.

Resistance Measurement Accuracy (4 wire remote sense)

Source I Mode, Auto Ohms

Range	Max. Resolution	Default Test Current	Normal Accuracy (23°C ± 5°C) 1 Year, ±(%rdg + ohms)	Enhanced Accuracy (23°C ± 5°C) [5] 1 Year, ±(%rdg + ohms)
<0.20000 Ω [4]	1 µΩ	—	Source I_{Acc} + Measure V_{Acc}	Measure I_{Acc} + Measure V_{Acc}
2.00000 Ω	10 µΩ	1 A	0.169% +0.0003 Ω	0.129% +0.0001 Ω
20.0000 Ω	100 µΩ	100 mA	0.098% + 0.003 Ω	0.073% + 0.001 Ω
200.000 Ω	1 mΩ	10 mA	0.077% + 0.03 Ω	0.053% + 0.01 Ω
2.00000 kΩ	10 mΩ	1 mA	0.066% + 0.3 Ω	0.045% + 0.1 Ω
20.0000 kΩ	100 mΩ	100 µA	0.063% + 3 Ω	0.043% + 1 Ω
200.000 kΩ	1 Ω	10 µA	0.065% + 30 Ω	0.046% + 10 Ω
2.00000 MΩ	10 Ω	10 µA	0.068% + 100 Ω	0.049% + 50 Ω
20.0000 MΩ	100 Ω	1 µA	0.249% + 1 kΩ	0.112% + 500 Ω
>20.0000 MΩ [4]	1 kΩ	—	Source I_{Acc} + Measure V_{Acc}	Measure I_{Acc} + Measure V_{Acc}

TEMPERATURE COEFFICIENT (0°–18°C & 28°–50°C): ±(0.15 × accuracy specification)/°C.

SOURCE I MODE, MANUAL OHMS: Total uncertainty = I source accuracy + V measure accuracy (4-wire remote sense).

SOURCE V MODE: Total uncertainty = V source accuracy + I measure accuracy (4-wire remote sense).

6-WIRE OHMS MODE: Available using active ohms guard and guard sense. **Max. Guard Output Current:** 50 mA (except 1A and 3A ranges). Accuracy is load dependent. Refer to manual for calculation formula.

GUARD OUTPUT IMPEDANCE: 0.1Ω in ohms mode.

[1] Speed = Normal (1 PLC).
[2] Accuracies apply to 2- or 4-wire mode when properly zeroed.
[3] 4-wire mode.
[4] Manual ohms mode only.
[5] Source readback enabled, offset compensation ON.

SYSTEM SPEEDS

MEASUREMENT[1]

MAXIMUM RANGE CHANGE RATE: 65/second.

MAXIMUM MEASURE AUTORANGE TIME: 40ms (fixed source)[2].

SWEEP OPERATION[3] READING RATES (rdg/second) FOR 60Hz (50Hz):

Speed	NPLC/Trigger Origin	Measure		Source-Measure		Source-Measure Pass/Fail Test[4]		Source-Memory[4]	
		To Mem.	To GPIB	To Mem.	To GPIB	To Mem.	To GPIB	To Mem.	To GPIB
Fast	0.01 / internal	2125(2010)	1000(1000)	1675(1590)	900(900)	1000(990)	760(760)	200 (185)	200(185)
	0.01 / external	1250(1210)	910 (920)	1080(1035)	830(835)	940(910)	710(710)	195 (180)	195(180)
Medium	0.10 / internal	510 (435)	510 (435)	475 (410)	475(410)	400(355)	400(355)	155 (140)	155(140)
	0.10 / external	435 (380)	435 (380)	415 (365)	415(365)	390(345)	390(345)	150 (135)	150(135)
Normal	1.00 / internal	59 (49)	59 (49)	58 (48)	58 (48)	57 (48)	57 (48)	46 (39)	46 (39)
	1.00 / external	57 (48)	57 (48)	57 (47)	57 (47)	56 (47)	56 (47)	46 (39)	46 (39)

SINGLE READING OPERATION READING RATES (rdg/second) FOR 60Hz (50Hz):

Speed	NPLC/Trigger Origin	Measure To GPIB	Source-Measure[5] To GPIB	Source-Measure Pass/Fail Test[4,5] To GPIB
Fast	0.01 / internal	200(200)	65 (65)	65 (65)
Medium	0.10 / internal	160(150)	60 (60)	60 (58)
Normal	1.00 / internal	46 (40)	31 (28)	30 (28)

COMPONENT HANDLER INTERFACE TIME: [4,6]

Speed	NPLC/Trigger Origin	Measure Pass/Fail Test	Source Pass/Fail Test	Source-Measure Pass/Fail Test[7]
Fast	0.01 / external	0.96 ms (1.07 ms)	0.5 ms (0.5 ms)	4.0 ms (4.0 ms)
Medium	0.10 / external	2.5 ms (2.8 ms)	0.5 ms (0.5 ms)	5.5 ms (5.75 ms)
Normal	1.00 / external	17.5 ms (20.85 ms)	0.5 ms (0.5 ms)	20.5 ms (24 ms)

[1] Reading rates applicable for voltage or current measurements. Auto zero off, autorange off, filter off, display off, trigger delay = 0, source auto clear off, and binary reading format.

[2] Purely resistive load. 10µA range <65ms.

[3] 1000 point sweep was characterized with the source on a fixed range.

[4] Pass/Fail test performed using one high limit and one low math limit.

[5] Includes time to re-program source to a new level before making measurement.

[6] Time from falling edge of START OF TEST signal to falling edge of END OF TEST signal.

[7] Command processing time of :SOURce:VOLTage|CURRent:TRIGgered <nrf> command not included.

GENERAL

NOISE REJECTION:

	NPLC	NMRR	CMRR
Fast	0.01	—	80 dB
Medium	0.1	—	80 dB
Normal	1	60 dB	120 dB [1]

LOAD IMPEDANCE: Stable into 20,000pF typical.

COMMON MODE VOLTAGE: 250VDC.

COMMON MODE ISOLATION: >$10^9\Omega$, <1000pF.

OVERRANGE: 105% of range, source and measure.

MAX. VOLTAGE DROP BETWEEN INPUT/OUTPUT AND SENSE TERMINALS: 5 volts.

MAX. SENSE LEAD RESISTANCE: 1MΩ for rated accuracy.

SENSE INPUT IMPEDANCE: >$10^{10}\Omega$.

GUARD OFFSET VOLTAGE: 300µV, typical.

SOURCE OUTPUT MODES:
Fixed DC level
Memory List (mixed function)
Stair (linear and log)

SOURCE MEMORY LIST: 100 points max.

MEMORY BUFFER: 5,000 readings @ 5½ digits (two 2,500 point buffers). Includes selected measured value(s) and time stamp. Lithium battery backup (3 yr+ battery life).

PROGRAMMABILITY: IEEE-488 (SCPI-1996.0), RS-232, 5 user-definable power-up states plus factory default and *RST.

DIGITAL INTERFACE:

Safety Interlock: Active low input.

Handler Interface: Start of test, end of test, 3 category bits. +5V @ 300mA supply.

Digital I/O: 1 trigger input, 4 TTL/Relay Drive outputs (33V @ 500mA sink, diode clamped).

POWER SUPPLY: 90V to 250V rms, 50–60Hz, 220VA.

COOLING: Forced air, variable speed.

WARRANTY: 1 year.

EMC: Conforms with European Union Directive 89/336/EEC EN 55011, EN 50082-1, EN 61000-3-2 and 61000-3-3, FCC part 15 class B.

SAFETY: Conforms with European Union Directive 73/23/EEC EN 61010-1, UL 3111-1.

VIBRATION: MIL-T-28800E Type III, Class 5.

WARM-UP: 1 hour to rated accuracies.

DIMENSIONS: 89mm high × 213mm wide × 370mm deep (3½in × 8⅜ in × 14⁹⁄₁₆ in). Bench Configuration (with handle & feet): 104mm high × 238mm wide × 370mm deep (4⅛ in × 9⅜ in × 14⁹⁄₁₆ in).

WEIGHT: 3.68kg (8.1 lbs).

ENVIRONMENT:

Operating: 0°–50°C, 70% R.H. up to 35°C. Derate 3% R.H./°C, 35°–50°C.

Storage: –25°C to 65°C.

[1] Except lowest current range = 90dB.

Specifications subject to change without notice.

Accuracy calculations

The information below discusses how to calculate accuracy for both measurement and source functions.

Measurement accuracy

Measurement accuracy is calculated as follows:

Accuracy = ±(% of reading + offset)

As an example of how to calculate the actual reading limits, assume that you are measuring 10V on the 20V range. You can compute the reading limit range from one-year measure voltage accuracy specifications as follows:

Accuracy = ±(% of reading + offset)
±[(0.015% X 10V) + 1mV]
±(1.5mV + 1mV)
±2.5mV

Thus, the actual reading range is: 10V± 2.5mV, or from 9.9975 to 10.0025V

Current measurement calculations are performed in exactly the same manner using the pertinent specifications, ranges, and input signal values.

Source accuracy

Source accuracy is calculated similarly, except of course that source specifications are used. As an example of how to calculate the actual source output limits, assume that you are sourcing 0.7mA on the 1mA source range. You can compute the reading limit range from source current one-year accuracy specifications as follows:

Accuracy = ±(0.034% of output + 200nA offset)
±[(0.034% X 0.7mA) + 200nA)]
±(238nA + 200nA)
±438nA

In this case, the actual current output range is: 0.7mA ±438nA, or from 0.69956mA to 0.70044mA

B
Command Reference

Introduction

This appendix contains detailed information on the various Model 2420 remote calibration commands, calibration error messages, and methods to detect the end of each calibration step.

Section 2 of this manual covers detailed calibration procedures.

Command summary

Table B-1 summarizes Model 2420 calibration commands. These commands are covered in detail in the following paragraphs.

Table B-1
Remote calibration command summary

Command	Description
:CALibration	Calibration subsystem.
:PROTected	Cal commands protected by password.
:CODE '<password>'	Unlock cal; if cal is unlocked, changes password. (Default password: KI002420.)
:COUNT?	Query number of times 2420 has been calibrated.
:SAVE	Save calibration data to EEPROM.*
:LOCK	Lock calibration, inhibit SAVE command operation.
:LOCK?	Request cal lock status. (0 = unlocked; 1= locked.)
:DATE <y>,<m>,<d>	Program calibration year, month, day.
:DATE?	Query calibration year, month, day.
:NDUE <y>,<m>,<d>	Program calibration due year, month, day.
:NDUE?	Query calibration due year, month, day.
:SENSe <nrf>	Calibrate active measure range.
:DATA?	Query measurement cal constants for active range.
:SOURce <nrf>	Calibrate active source range.
:DATA?	Query source cal constants for active range.

* Calibration data will not be saved if:

1. Calibration was not unlocked with :CODE command.
2. Invalid data exists. (For example, cal step failed or was aborted.)
3. Incomplete number of cal steps were performed. (For example, omitting a negative full-scale step.) Ranges that were successfully calibrated will be saved if calibration is unlocked. Ranges that failed will not be saved.

Miscellaneous commands

Miscellaneous commands are those commands that perform such functions as saving calibration constants, locking out calibration, and programming date parameters.

:CODE

(:CALibration:PROTected:CODE)

Purpose To unlock calibration so that you can perform the calibration procedures.

Format
```
:cal:prot:code '<password>'
```

Parameter Up to a 8-character string including letters and numbers.

Description The :CODE command sends the password and enables calibration when performing these procedures via remote. The correct password must be sent to the unit before sending any other calibration command. The default remote password is KI002420.

Note
- The :CODE command should be sent only once before performing calibration. Do not send :CODE before each calibration step.
- To change the code, first send the present code, then send the new code.
- The password parameter must be enclosed in single quotes.
- If you change the first two characters of the password to something other than "KI", you will not be able to unlock calibration from the front panel.

Example
```
:CAL:PROT:CODE 'KI002420'
```
Send default code of KI002420.

:COUNT?

(:CALibration:PROTected:COUNT?)

Purpose To request the number of times the Model 2420 has been calibrated.

Format
```
:cal:prot:count?
```

Response Number of times calibrated.

Description The :COUNT? query may be used to determine the total number of times the Model 2420 has been calibrated.

Example
```
:CAL:PROT:COUNT?
```
Request calibration count.

:LOCK

(:CALibration:PROTected:LOCK)

Purpose To lock out calibration.

Format
```
:cal:prot:lock
```

Query
```
:cal:prot:lock?
```

Response
- 0 Calibration unlocked
- 1 Calibration locked

Description The :LOCK command allows you to lock out comprehensive calibration after completing those procedures. Thus, :LOCK performs the opposite of sending the password with the :CODE command. The :LOCK? query returns calibration lock status.

Note To unlock calibration, send the :CODE command with the appropriate password.

Example
```
:CAL:PROT:LOCK
```
Lock out calibration

:SAVE

(:CALibration:PROTected:SAVE)

Purpose To save calibration constants in EEROM after the calibration procedure.

Format
```
:cal:prot:save
```

Description The :SAVE command stores internally calculated calibration constants derived during comprehensive in EEROM. EEROM is non-volatile memory, and calibration constants will be retained indefinitely once saved. Generally, :SAVE is sent after all other calibration steps (except for :LOCK).

Note Calibration will be only temporary unless the :SAVE command is sent to permanently store calibration constants. Calibration data will not be saved if: (1) calibration was not unlocked by sending the :CODE command, (2) invalid data exists (for example, cal step failed or was aborted.), or (3) an incomplete number of cal steps were performed (for example, omitting a negative full-scale step).

Example
```
:CAL:PROT:SAVE
```
Save calibration constants

:DATE

(:CALibration:PROTected:DATE)

Purpose To program the calibration date.

Format
```
:cal:prot:date <year>, <month>, <day>
```

Parameters
<year> = 1997 to 2096
<month> = 1 to 12
<day> = 1 to 31

Query
```
:cal:prot:date?
```

Response <year> , <month> , <day>

Description The :DATE command allows you to store the calibration date in instrument EEROM for future reference. You can read back the date from the instrument by using the :DATE? query, or by using the front panel CAL menu.

Note The year, month, and day parameters must be delimited by commas.

Example
```
:CAL:PROT:DATE 1997,11,20
```
Send cal date (11/20/97).

:NDUE

(:CALibration:PROTected:NDUE)

Purpose To send the next calibration due date to the instrument.

Format
```
:cal:prot:ndue <year>, <month>, <day>
```

Parameters <year> = 1997 to 2096
<month> = 1 to 12
<day> = 1 to 31

Query
```
:cal:prot:ndue?
```

Response <year>, <month>, <day>

Description The :NDUE command allows you to store the date when calibration is next due in instrument memory. You can read back the next due date by using the :NDUE? query, or by using the front panel CAL menu.

Note The next due date parameters must be delimited by commas.

Example
```
:CAL:PROT:NDUE 1998,11,20
```
Send due date (11/20/98).

:SENSE

(:CALibration:PROTected:SENSe)

Purpose To calibrate the sense function.

Format
```
:cal:prot:sens <nrf>
```

Parameters See Table B-2 for recommended parameter ranges for optimum calibration.

Description The :CAL:PROT:SENS command calibrates the Model 2420 sense function. To use this command, you must (1) program the source to the correct value, (2) select the range being calibrated, and (3) send the :CAL:PROT:SENS command for each parameter listed in Table B-2.

Note When the Model 2420 receives this command, it will attempt to place the parameter into one of the three parameter ranges summarized in Table B-2, depending on the active :SENS:FUNC and range. If the parameter does not fit into any of the three allowed ranges, an error number -222, "Parameter data out of range" will be generated. Once the unit has successfully selected the appropriate parameter range, it will then check to see if autorange for the active :SENS:FUNC is enabled. If so, an error number -221, "Settings conflict" will be generated. If no error occurs, the active sense function/range point will be calibrated using the corresponding parameter.

Note that parameters for a given sense function and range may be sent in any order; however, once one :CAL:PROT:SENS command executes, the other two must also be executed, or an error number -200, "Execution error" will occur when the :CAL:PROT:SAVE command is processed at the end of the calibration procedure.

Example
```
:CAL:PROT:SENS 2
```
Calibrate 2V sense range.

Table B-2
Recommended :CALibration:PROTected:SENSe parameter ranges

Sense range	First parameter (zero)	Second parameter (negative full scale)	Third parameter (positive full scale)
0.2V	0.002 to +0.002	-0.18 to -0.22	+0.18 to +0.22
2V	0.02 to +0.02	-1.8 to -2.2	+1.8 to +2.2
20V	0.2 to +0.2	-18 to -22	+18 to +22
60V	0.5 to +0.5	-50 to -65	+50 to +65
10µA	-1E-7 to +1E-7	-9E-6 to -11E-6	+9E-6 to +11E-6
100µA	-1E-6 to +1E-6	-90E-6 to -110E-6	+90E-6 to +110E-6
1mA	-1E-5 to +1E-5	-0.9E-3 to -1.1E-3	+0.9E-3 to +1.1E-3
10mA	-1E-4 to +1E-4	-9E-3 to -11E-3	+9E-3 to +11E-3
100mA	-1E-3 to +1E-3	-90E-3 to -110E-3	+90E-3 to +110E-3
1A	-1E-2 to +1E-2	-0.9 to -1.1	+0.9 to +1.1
3A	-3E-2 to 3E-2	-2.7 to -3.15	+2.7 to +3.15

Note: Actual allowable parameter ranges are ±50% of full range for zero parameters, 75% of full scale to 150% of full scale for full-range parameters, but ranges listed above should be observed for optimum calibration.

:SOURCE

(:CALibration:PROTected:SOURce)

Purpose To calibrate the source function.

Format `:cal:prot:sour <nrf>`

Parameters See Table B-3 for recommended parameter ranges.

Description The :CAL:PROT:SOUR command calibrates the Model 2420 source function. To use this command, you must (1) program the source to the correct value, (2) select the range being calibrated, and (3) send the :CAL:PROT:SOUR command for each parameter listed in Table B-3.

Note When the Model 2420 receives this command, it will attempt to place the parameter into one of the four parameter ranges summarized in Table B-3, depending on the active :SOUR:FUNC and range. If the parameter does not fit into any of the four allowed ranges, an error number -222, "Parameter data out of range" will be generated. Once the unit has successfully selected the appropriate parameter range, it will then check to see if if the active source is programmed to a value within the selected parameter range, and that :OUTP:STAT is ON. If the active source is not programmed to a value within the parameter range (or if the source is in autorange or in standby), an error number -221, "Settings conflict" will be generated. If no error occurs, the active source function/range point will be calibrated using the corresponding parameter.

Note that parameters for a given source function and range may be sent in any order; however, once one :CAL:PROT:SOUR command executes, the other three must also be executed, or an error number -200, "Execution error" will occur when the :CAL:PROT:SAVE command is processed at the end of the calibration procedure.

Because the source is calibrated for both positive and negative values, two zero calibration points are required. The Model 2420 automatically uses the appropriate zero parameter based on whether the source polarity is positive or negative.

Example `:CAL:PROT:SOUR 2` Calibrate 2V source range.

Table B-3
Recommended:CALibration:PROTected:SOURce parameter ranges

Source range	First parameter (negative full scale)	Second parameter (negative zero)	Third parameter (positive full scale)	Fourth parameter (positive zero)
0.2V	-0.18 to -0.22	-0.002 to +0.002	+0.18 to +0.22	-0.002 to +0.002
2V	-1.8 to -2.2	-0.02 to +0.02	+1.8 to +2.2	-0.02 to +0.02
20V	-18 to -22	-0.2 to +0.2	+18 to +22	-0.2 to +0.2
60V	-50 to -65	-0.5 to +0.5	+50 to +65	-0.5 to +0.5
10µA	-9E-6 to -11E-6	-1E-7 to +1E-7	+9E-6 to +11E-6	-1E-7 to +1E-7
100µA	-90E-6 to -110E-6	-1E-6 to +1E-6	+90E-6 to +110E-6	-1E-6 to +1E-6
1mA	-0.9E-3 to -1.1E-3	-1E-5 to +1E-5	+0.9E-3 to +1.1E-3	-1E-5 to +1E-5
10mA	-9E-3 to -11E-3	-1E-4 to +1E-4	+9E-3 to +11E-3	-1E-4 to +1E-4
100mA	-90E-3 to -110E-3	-1E-3 to +1E-3	+90E-3 to +110E-3	-1E-3 to +1E-3
1A	-0.9 to -1.1	-1E-2 to +1E-2	+0.9 to +1.1	-1E-2 to +1E-2
3A	-2.7 to -3.15	-3E-2 to +3E-2	+2.7 to +3.15	-3E-2 to +3E-2

Note: Actual allowable parameter ranges are ±50% of full range for zero parameters, 75% of full scale to 150% of full scale for full-range parameters, but ranges listed above should be observed for optimum calibration.

:DATA?

(:CALibration:PROTected:SENSe:DATA?)

(:CALibration:PROTected:SOURce:DATA?)

Purpose To request the calibration constants for the active range.

Format
```
:cal:prot:sens:data?
:cal:prot:sour:data?
```

Response Four comma-separated ASCII floating-point constants

Description The :CAL:PROT:SENS:DATA? and :CAL:PROT:SOUR:DATA? queries request the calibration constants for the active range of the sense and source functions respectively. The four returned constants are in ASCII floating-point format delimited by commas.

Note To request the appropriate constants, (1) select the source or sense function, (2) choose the desired range, and (3) send the desired :DATA? query.

Example
```
:SENS:FUNC 'VOLT:DC'        Select DC sense function.
:SENS:VOLT:DC:RANGE 0.2     Choose 200mV range.
:CAL:PROT:SENS:DATA?        Request cal constants.
```

Detecting calibration errors

If an error occurs during any calibration step, the Model 2420 will generate an appropriate error message. Several methods to detect calibration errors are discussed below.

Reading the error queue

As with other Model 2420 errors, any calibration errors will be reported in the error queue. (You can read the error queue by using the :SYST:ERR? query.)

Error summary

Table B-4 summarizes calibration errors. These errors will occur under the following conditions.

Error 500/501 — These errors will occur if you do not set the calibration date or calibration due date.

Error 502 — This error will occur when the :CAL:PROT:SENS or :CAL:PROT:SOUR command is sent with a parameter that cannot be placed into any of the defined numeric ranges.

Error 503/504 — Will occur when the source/compliance DAC calibration constants generate an invalid DAC setting. All of the source/compliance DAC calibration constants are verified each time a :CAL:PROT:SOUR command is processed and when the Model 2420 is first turned on. This error generally occurs when the Model 2420 source circuitry is defective.

Error 505 — Will occur when a :CAL:PROT:SOUR command generates an invalid source offset calibration constant.

Error 506 — Will occur when a :CAL:PROT:SOUR command generates an invalid source gain calibration constant.

Error 507 — Will occur when a :CAL:PROT:SENS command generates an invalid measurement offset calibration constant.

Error 508 — Will occur when a :CAL:PROT:SENS command generates an invalid measurement gain calibration constant.

Table B-4
Calibration errors

Error number	Error message
+500	"Date of calibration not set"
+501	"Next date of calibration not set"
+502	"Calibration data invalid"
+503	"DAC calibration overflow"
+504	"DAC calibration underflow"
+505	"Source offset data invalid"
+506	"Source gain data invalid"
+507	"Measurement offset data invalid"
+508	"Measurement gain data invalid"

Status byte EAV (Error Available) bit

Whenever an error is available in the error queue, the EAV (Error Available) bit (bit 2) of the status byte will be set. Use the *STB? query to obtain the status byte, then test bit 2 to see if it is set. If the EAV bit is set, an error has occurred, and you can use the appropriate error query to read the error and at the same time clear the EAV bit in the status byte.

Generating an SRQ on error

To program the instrument to generate an IEEE-488 bus SRQ (Service Request) when an error occurs, send the following command: *SRE 4. This command will enable SRQ when the EAV bit is set. You can then read the status byte and error queue as outlined above to check for errors and to determine the exact nature of the error.

Detecting calibration step completion

When sending remote calibration commands, you must wait until the instrument completes the current operation before sending another command. You can use either *OPC? or *OPC to help determine when each calibration step is completed.

Using the *OPC? query

With the *OPC? (operation complete) query, the instrument will place an ASCII 1 in the output queue when it has completed each step. To determine when the OPC response is ready, do the following:

1. Repeatedly test the MAV (Message Available) bit (bit 4) in the status byte and wait until it is set. (You can request the status byte by using the *STB? query.)
2. When MAV is set, a message is available in the output queue, and you can read the output queue and test for an ASCII 1.
3. After reading the output queue, repeatedly test MAV again until it clears. At this point, the calibration step is completed.

Using the *OPC command

The *OPC (operation complete) command can also be used to detect the completion of each calibration step. In order to use *OPC to detect the end of each calibration step, do the following:

1. Enable operation complete by sending *ESE 1. This command sets the OPC (operation complete bit) in the standard event enable register, allowing operation complete status from the standard event status register to set the ESB (event summary bit) in the status byte when operation complete is detected.
2. Send the *OPC command immediately following each calibration command. For example:

   ```
   :CAL:PROT:SENS 2;*OPC
   ```

   Note that you must include the semicolon (;) to separate the two commands, and that the *OPC command must appear on the same line as the command.
3. After sending a calibration command, repeatedly test the ESB (Event Summary) bit (bit 5) in the status byte until it is set. (Use *STB? to request the status byte.)
4. Once operation complete has been detected, clear OPC status using one of two methods: (1) use the *ESR? query, then read the response to clear the standard event status register, or (2) send the *CLS command to clear the status registers. Note that sending *CLS will also clear the error queue and operation complete status.

Generating an SRQ on calibration complete

An IEEE-488 bus SRQ (service request) can be used to detect operation complete instead of repeatedly polling the Model 2420. To use this method, send both *ESE 1 and *SRE 32 to the instrument, then include the *OPC command at the end of each calibration command line, as covered above. Clear the SRQ by querying the ESR (using the *ESR? query) to clear OPC status, then request the status byte with the *STB? query.

Refer to your controller's documentation for information on detecting and servicing SRQs.

C
Calibration Programs

Introduction

This appendix includes a calibration program written in BASIC to help you in calibrate the Model 2420, as well as an example program that demonstrates how to request calibration constants. Refer to Section 2 for more details on calibration procedures, equipment, and connections. Appendix B covers calibration commands in detail.

Computer hardware requirements

The following computer hardware is required to run the calibration programs:

- IBM PC compatible computer.
- Keithley KPC-488.2, KPS-488.2, or KPC-488.2AT, or CEC PC-488 IEEE-488 interface for the computer.
- Two shielded IEEE-488 connecting cables (Keithley Model 7007)

Software requirements

In order to use the calibration programs, you will need the following computer software:

- Microsoft QBasic (supplied with MS-DOS 5.0 or later).
- MS-DOS version 5.0 or later.
- HP-style Universal Language Driver, CECHP.EXE (supplied with Keithley and CEC interface cards listed above).

Calibration equipment

The following calibration equipment is required:

- Hewlett-Packard HP3458A Digital Multimeter
- 1Ω, ±0.1%, 100W resistor

See Section 2 for detailed equipment specifications.

General program instructions

1. With the power off, connect the Model 2420 and the digital multimeter to the IEEE-488 interface of the computer. Be sure to use shielded IEEE-488 cables for bus connections.
2. Turn on the computer, the Model 2420, and the digital multimeter. Allow the Model 2420 and the multimeter to warm up for at least one hour before performing calibration.
3. Make sure the Model 2420 is set for a primary address of 24. (Use the front panel MENU/GPIB selection to check or change the address.)

4. Make sure the digital multimeter primary address is set to its factory default setting (22).
5. Make sure that the computer bus driver software (CECHP.EXE) is properly initialized.
6. Enter the QBasic editor, and type in the program below.

NOTE *Be sure to change the OneOhm parameter to the characterized value of 1Ω resistor. (See Section 2 for details.)*

7. Check thoroughly for errors, then save it using a convenient filename.
8. Run the program, and follow the prompts on the screen to perform calibration. For test connections, refer to the following figures in Section 2:

- DMM volts connections: Figure 2-1.
- 10μA to 1A range current connections: Figure 2-2.
- 1Ω resistor and DMM connections for 3A range: Figure 2-3.

Program C-1 Model 2420 calibration program

' Model 2420 calibration program for use with the HP3458A Digital Multimeter.

```
' Rev. 1.0, 1/16/97
' 2420 primary address = 24. HP3458A primary address = 22.
OPEN "IEEE" FOR OUTPUT AS #1            ' Open IEEE-488 output path.
OPEN "IEEE" FOR INPUT AS #2             ' Open IEEE-488 input path.
PRINT #1, "INTERM CRLF"                 ' Set input terminator.
PRINT #1, "OUTTERM LF"                  ' Set output terminator.
PRINT #1, "REMOTE 22 24"                ' Put 2420, 3458A in remote.
PRINT #1, "CLEAR"                       ' Send DCL.
PRINT #1, "OUTPUT 24;*CLS"              ' Initialize 2420.
PRINT #1, "OUTPUT 24;*ESE 1;*SRE 32"    ' Enable OPC and SRQ.
PRINT #1, "OUTPUT 22;PRESET NORM"       ' Initialize 3458A.
PRINT #1, "OUTPUT 22;NPLC 10;NDIG 7;TRIG LINE;FUNC DCV,AUTO"
'
OneOhm = 1                              ' Use characterized 1 ohm value.
CLS
PRINT "Model 2420 Calibration Program"
PRINT "Connect DMM volts input to Model 2420 INPUT/OUTPUT jacks."
GOSUB KeyCheck
FOR J = 1 TO 2                          ' Select volts/current cal.
IF J = 1 THEN
        RESTORE VoltsInit
        Max = 8
        Range = .2
        Limit = 60
ELSE
        RESTORE CurrentInit
        Max = 4
        Range = .00001
        Limit = 3
        PRINT #1, "OUTPUT 24;:OUTP:STAT OFF"
        PRINT #1, "OUTPUT 22;FUNC DCI,AUTO"
        PRINT "Connect DMM current input to 2420 INPUT/OUTPUT jacks."
        GOSUB KeyCheck
END IF
Source = Range
FOR I = 1 TO Max: READ Cmd$: PRINT #1, "OUTPUT 24;"; Cmd$: NEXT I
WHILE Range <= Limit                    ' Cal all ranges.
IF J = 1 THEN RESTORE VoltsCal ELSE RESTORE CurrentCal
FOR I = 1 TO 12
        READ Cmd$
        SELECT CASE I
                CASE 1
                        PRINT #1, "OUTPUT 24;"; Cmd$; Range
                CASE 2
                        PRINT #1, "OUTPUT 24;"; Cmd$; -Source
                        GOSUB ReadDMM
                CASE 3, 4, 6, 7, 9, 10, 12
                        PRINT #1, "OUTPUT 24;"; Cmd$; Reading$; ";*OPC"
                        GOSUB ErrCheck
```

```
                        GOSUB CalEnd
                CASE 5, 11
                        PRINT #1, "OUTPUT 24;"; Cmd$
                        GOSUB ReadDMM
                CASE 8
                        PRINT #1, "OUTPUT 24;"; Cmd$; Source
                        GOSUB ReadDMM
        END SELECT
NEXT I
Range = Range * 10
IF J = 1 AND Range = 200 THEN Range = 60
IF J = 2 AND Range > 9 AND Range < 11 THEN
        Range = 3
        PRINT #1, "OUTPUT 24;:OUTP:STAT OFF"
        PRINT #1, "OUTPUT 22;FUNC DCV,AUTO"
        PRINT "Connect 1 Ohm resistor and DMM volts input to 2420."
        GOSUB KeyCheck
        PRINT #1, "OUTPUT 24;:OUTP:STAT ON"
END IF
Source = Range
WEND
NEXT J
PRINT #1, "OUTPUT 24;:OUTP:STAT OFF"
LINE INPUT "Enter calibration date (yyyy,mm,dd): "; D$
PRINT #1, "OUTPUT 24;:CAL:PROT:DATE "; D$
LINE INPUT "Enter calibration due date (yyyy,mm,dd): "; D$
PRINT #1, "OUTPUT 24;:CAL:PROT:NDUE "; D$
PRINT #1, "OUTPUT 24;:CAL:PROT:SAVE"    ' Save calibration constants.
GOSUB ErrCheck
PRINT #1, "OUTPUT 24;:CAL:PROT:LOCK"    ' Lock out calibration.
PRINT "Calibration completed."
PRINT #1, "OUTPUT 24;*RST"
PRINT #1, "LOCAL 22 24"
CLOSE
END
'
KeyCheck:                               ' Check for key press routine.
WHILE INKEY$ <> "": WEND                ' Flush keyboard buffer.
PRINT : PRINT "Press any key to continue (ESC to abort program)."
DO: I$ = INKEY$: LOOP WHILE I$ = ""
IF I$ = CHR$(27) THEN GOTO EndProg      ' Abort if ESC is pressed.
RETURN
'
CalEnd:                                 ' Check for cal step completion.
DO: PRINT #1, "SRQ?"                    ' Request SRQ status.
        INPUT #2, S                     ' Input SRQ status byte.
LOOP UNTIL S                            ' Wait for operation complete.
PRINT #1, "OUTPUT 24;*ESR?"             ' Clear OPC.
PRINT #1, "ENTER 24"
INPUT #2, S
PRINT #1, "SPOLL 24"                    ' Clear SRQ.
```

```
INPUT #2, S
RETURN
'
ErrCheck:                                ' Error check routine.
PRINT #1, "OUTPUT 24;:SYST:ERR?"         ' Query error queue.
PRINT #1, "ENTER 24"
INPUT #2, E, Err$
IF E <> 0 THEN PRINT Err$: GOTO EndProg' Display error.
RETURN
'
ReadDMM:                                 ' Get reading from DMM.
SLEEP 5
PRINT #1, "ENTER 22"
INPUT #2, Reading$
IF J = 2 AND Range = 3 THEN Reading$ = STR$(VAL(Reading$) / OneOhm)
RETURN
'
EndProg:                                 ' Close files, end program.
BEEP: PRINT "Calibration aborted."
PRINT #1, "OUTPUT 24;:CAL:PROT:LOCK"
PRINT #1, "OUTPUT 24;*RST"
PRINT #1, "LOCAL 22 24"
CLOSE
END
'
VoltsInit:                               ' Calibration command lists.
DATA "*RST",":SOUR:FUNC VOLT",":SENS:CURR:PROT 0.1"
DATA ":SENS:CURR:RANG 0.1",":SOUR:VOLT:PROT:LEV MAX",":SYST:RSEN OFF"
DATA ":CAL:PROT:CODE 'KI002420'",":OUTP:STAT ON"
VoltsCal:
DATA ":SOUR:VOLT:RANG ",":SOUR:VOLT "
DATA ":CAL:PROT:SOUR ",":CAL:PROT:SENS ",":SOUR:VOLT 0.0"
DATA ":CAL:PROT:SOUR ",":CAL:PROT:SENS ",":SOUR:VOLT ",":CAL:PROT:SOUR "
DATA ":CAL:PROT:SENS ",":SOUR:VOLT 0.0",":CAL:PROT:SOUR "
CurrentInit:
DATA ":SOUR:FUNC CURR",":SENS:VOLT:PROT 20",":SENS:VOLT:RANG 20"
DATA ":OUTP:STAT ON"
CurrentCal:
DATA ":SOUR:CURR:RANG ",":SOUR:CURR ",":CAL:PROT:SOUR "
DATA ":CAL:PROT:SENS ",":SOUR:CURR 0.0",":CAL:PROT:SOUR ",":CAL:PROT:SENS "
DATA ":SOUR:CURR ",":CAL:PROT:SOUR ",":CAL:PROT:SENS "
DATA ":SOUR:CURR 0.0",":CAL:PROT:SOUR "
```

Requesting calibration constants

Program C-2 listed below demonstrates how to request the calibration constants from the Model 2420. The program requests and displays the calibration constants for all ranges of both the volts and current source and measurement functions.

Program C-2 Requesting calibration constants

```
' Example program to request calibration constants.
' Model 2420 primary address = 24
OPEN "IEEE" FOR OUTPUT AS #1            ' Open IEEE-488 output path.
OPEN "IEEE" FOR INPUT AS #2             ' Open IEEE-488 input path.
PRINT #1, "INTERM CRLF"                 ' Set input terminator.
PRINT #1, "OUTTERM LF"                  ' Set output terminator.
PRINT #1, "REMOTE 24"                   ' Put 2420 in remote.
PRINT #1, "OUTPUT 24;*RST"              ' Restore defaults.
CLS
PRINT #1, "OUTPUT 24;:SENS:FUNC:CONC OFF"
PRINT #1, "OUTPUT 24;:SENS:FUNC 'VOLT:DC'"
PRINT #1, "OUTPUT 24;:SOUR:FUNC VOLT"
PRINT #1, "OUTPUT 24;:CAL:PROT:CODE 'KI002420'" ' Unlock calibration.
Range = .2                              ' Initial range = 200mV.
PRINT "Model 2420 Voltage Calibration Constants:": PRINT
DO                                      ' Loop for all volts ranges.
        PRINT #1, "OUTPUT 24;:SOUR:VOLT:RANGE "; Range
        PRINT #1, "OUTPUT 24;:CAL:PROT:SENS:DATA?"
        PRINT #1, "ENTER 24"
        LINE INPUT #2, Data$
        PRINT Data$
        PRINT #1, "OUTPUT 24;:CAL:PROT:SOUR:DATA?"
        PRINT #1, "ENTER 24"
        LINE INPUT #2, Data$
        PRINT Data$
        Range = Range * 10
        IF Range = 200 THEN Range = 60
LOOP WHILE Range <= 60
PRINT #1, "OUTPUT 24;:CAL:PROT:LOCK"
PRINT #1, "OUTPUT 24;:SENS:FUNC 'CURR:DC'"
PRINT #1, "OUTPUT 24;:SOUR:FUNC CURR"
PRINT #1, "OUTPUT 24;:CAL:PROT:CODE 'KI002420'"
Range = .00001                          ' Initial range = 10uA.
PRINT : PRINT "Model 2420 Current Calibration Constants:": PRINT
DO                                      ' Loop for all current ranges.
        PRINT #1, "OUTPUT 24;:SOUR:CURR:RANGE "; Range
        PRINT #1, "OUTPUT 24;:CAL:PROT:SENS:DATA?"
        PRINT #1, "ENTER 24"
        LINE INPUT #2, Data$
        PRINT Data$
        PRINT #1, "OUTPUT 24;:CAL:PROT:SOUR:DATA?"
        PRINT #1, "ENTER 24"
```

```
        LINE INPUT #2, Data$
        PRINT Data$
        Range = Range * 10
        IF Range > 9 AND Range < 11 THEN Range = 3
LOOP WHILE Range <= 3
PRINT #1, "OUTPUT 24;:CAL:PROT:LOCK"     ' Lock out calibration.
PRINT #1, "OUTPUT 24;*RST"
PRINT #1, "LOCAL 24"
CLOSE
END
```

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Service Form

Model No. _____ **Serial No.**_____ **Date**_____

Name and Telephone No. _____

Company _____

List all control settings, describe problem and check boxes that apply to problem. _____

_____

_____

❑ Intermittent ❑ Analog output follows display ❑ Particular range or function bad; specify

_____

❑ IEEE failure ❑ Obvious problem on power-up ❑ Batteries and fuses are OK

❑ Front panel operational ❑ All ranges or functions are bad ❑ Checked all cables

Display or output (check one)

❑ Drifts ❑ Unable to zero ❑ Unstable

❑ Overload ❑ Will not read applied input

❑ Calibration only ❑ Certificate of calibration required ❑ Data required

(attach any additional sheets as necessary)

Show a block diagram of your measurement including all instruments connected (whether power is turned on or not). Also, describe signal source.

Where is the measurement being performed? (factory, controlled laboratory, out-of-doors, etc.)_____

_____

What power line voltage is used?_____ Ambient temperature?_____ °F

Relative humidity? _____ Other?_____

Any additional information. (If special modifications have been made by the user, please describe.)

_____

_____

Be sure to include your name and phone number on this service form.

1. What other Keithley products do you currently use?

2. What effects, devices or phenomena do you measure with this instrument?

3. What was the main reason a *Keithley* unit was purchased?

4. Do you have any design suggestions concerning this unit?

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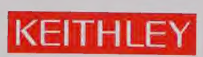

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